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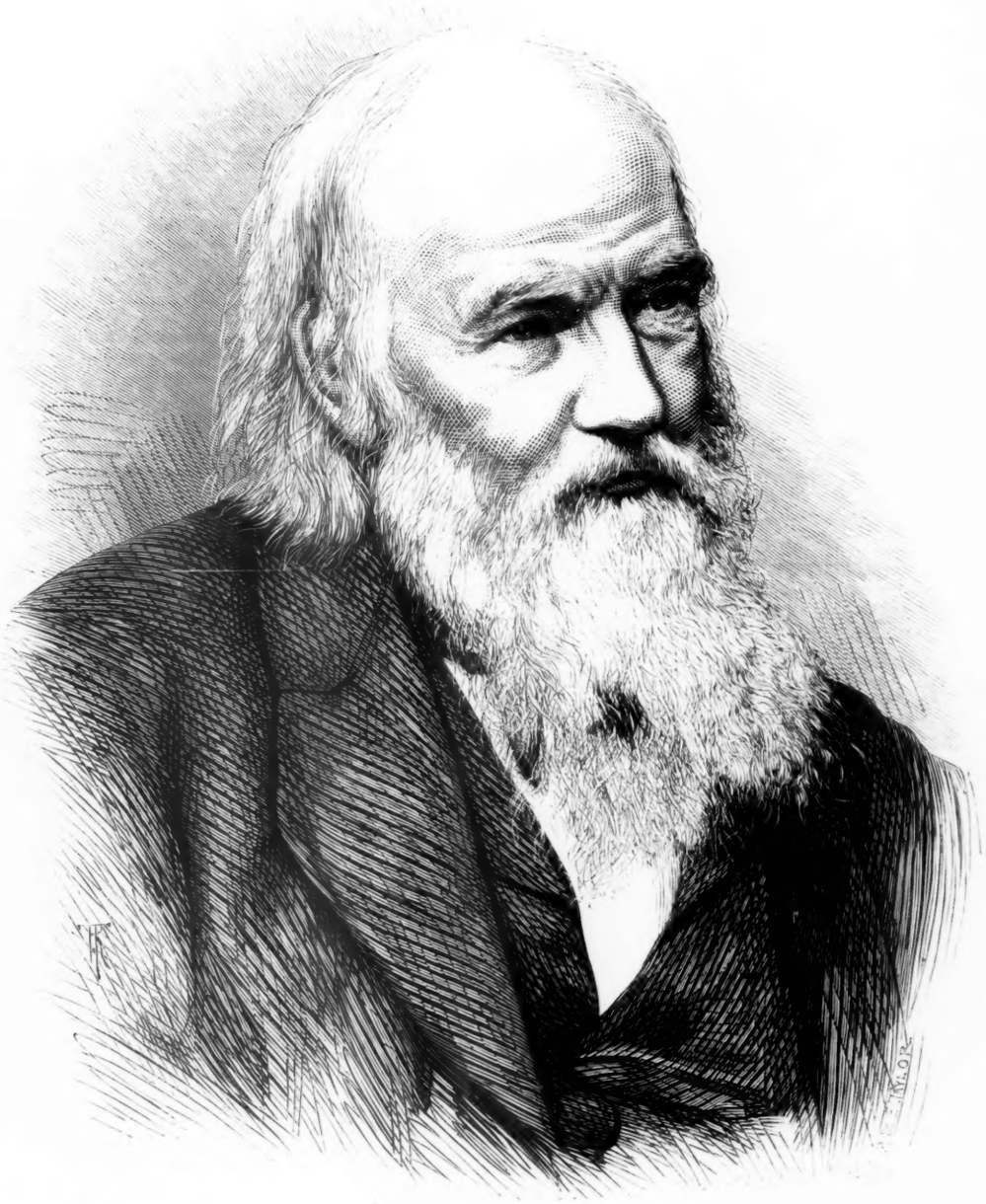


MR. JAMES YOUNG.

MR. JAMES YOUNG AND THE PARAFFIN-OIL TRADE OF SCOTLAND.

IT is the purpose of this paper to trace, collaterally with the career of its founder, the progress of the paraffin-oil industry of Scotland. Probably no industry extant has attained within an equally short time such colossal proportions. Thirty years ago, the term paraffin was known only to scientific men, as the name of a chemical product evolved from the distillation of beechwood and Rangoon tar. But the quantities of it so obtained were too infinitesimal to be of any value as an article of commerce. Its commercial utility was therefore *nil*, and it was regarded more as a scientific curiosity than in any other light. Yet it was a dream of several eminent chemists that paraffin or some substitute for it possessing kindred properties, might be obtained for illuminating purposes. Liebeg, in his "Familiar Letters on Chemistry," opined that olefiant gas might be obtained in a solid form, suitable for burning in a candlestick, and Reichenbach, the no less eminent German chemist, who first discovered it as an ingredient in the tar obtained from the distillation of beechwood, also looked forward to the time when paraffin would be obtained in large quantities, and made an article of commercial value.

Such was the state of matters that prevailed in the earlier half of the nineteenth century. We who live in the other half can scarcely realize the difficulties under which our fathers laboured in the matter of obtaining artificial light. Gas was not then the common-place luxury that it has since become. Accessible enough in large cities, it was conspicuous by its absence in many second and third-rate towns. In the country, tallow-candles, sperm oil, and "fat sticks," were the only auxiliaries to the light obtained from the fire on the hearth. The expiring cry of Goethe for "Light, more light," was heard, in a more literal definition, all the world over. Civilization imperatively demanded that science should unfold from her hidden treasures other and more satisfactory means of illumination. At this juncture, the arcana of nature was in course of being penetrated. The light to lighten the "dark places of the earth" was about to be revealed.

James Young was the son of a joiner who carried on business in the Drygate of Glasgow—one of the most thickly-populated districts in the east end. The sire had not the means wherewith to bestow upon the son more than the rudiments of an ordinary English education. Taken from school at an early age, the latter was destined by his father to follow the trade of a joiner, and actually worked thereat for a considerable time. But he found ways and means

> "To burst his birth's invidious bar,
> Breasting the blows of circumstance,
> To grasp the skirts of happy chance,
> And grapple with his evil star."

His spare hours were diligently employed in the study of chemistry. His instructor was Professor Graham, afterwards Master of the Mint, and one of the first to shed upon the chemical chair in the Andersonian University of Glasgow, the exceptional lustre it now enjoys. Graham was not slow to perceive that his pupil was a more than usually apt scholar. He therefore took the utmost pains in his tuition, and was so satisfied with the results, that eventually Mr. Young was made his class-assistant. From the joiner's bench to the chemical class-room and laboratory was neither an easy nor a natural transition; but it was one to which the subject of these remarks proved himself in all respects equal. Graham indeed had such a high opinion of his capacity that when he was appointed Professor of Chemistry in London University, he made arrangements for the renewal of the association which existed in Glasgow between himself and his former pupil. To London, then, Mr. Young removed, when little more than twenty years of age, and he continued to assist Graham in the laboratory and class-rooms of London University, as he had done in the Andersonian of Glasgow, until he was invited to become manager of Muspratt's Chemical Works at Newton, near Liverpool. At these works the manufacture of alkali and bleaching powder was then carried on to a larger extent perhaps than anywhere else in the kingdom. Mr. Young's appointment involved a large amount of responsibility, but he was not found wanting in any of the qualifications essential to the proper discharge of his duties. Anxious to mature his experience still further, he was induced to accept a managerial position in Tennant's Chemical Works, Manchester, after he had been four and a-half years with Muspratt. Tennant's concern was the largest of its kind in the world. The firm not only carried on large works at Manchester, but they had still larger establishments at Glasgow and Newcastle. From returns furnished by the firm to the Paris Industrial Exhibition of 1854, within ten years of the time when Mr. Young entered their employment, some idea of the magnitude of their operations may be obtained. During the year 1853, the firm made the following quantities of—

Soda-ash	12,000 tons.
Do. in Crystal	7,000 „
Bleaching Powder	7,000 „
Sulphuric Acid	2,000 „

The latter quantity of sulphuric acid was made for sale only; but the firm required some 14,000 tons per annum for their own use. In the course of this year also, the following materials were consumed:—

Coal	90,162 tons.
Limestone	30,000 „
Salt	17,000 „
Sulphur	5,600 „
Manganese	4,500 „

While he resided in Glasgow, Mr. Young made the acquaintance of Dr. Lyon Playfair—a most eminent chemist, and now member for the University of Edinburgh. Playfair had observed the practical and inquiring turn of Mr. Young's mind, and thus selected him as the proper man to investigate the properties of a petroleum spring which had been discovered in a coal mine in Derbyshire, belonging to his brother-in-law. Mr. Young readily accepted the commission. On examining the spring along with Dr. Playfair, he found petroleum dropping from the roof of the mine over the coal. Believing that he had got hold of a good thing, he took a lease of the mine, and worked the petroleum until it became exhausted. He had previously advised his employers in Manchester to take it up, but they replied that it was too small a matter for them to go into, and declined the offer. It was in the year 1848 that Mr. Young quitted Manchester to embark on this venture. He produced two different kinds of oil—one a thick oil for lubricating purposes, and the other a thin oil for lamp burning. As the petroleum spring became exhausted, Mr. Young made numerous experiments, with the view of finding an artificial substitute for the natural oil,—his experience having demonstrated that there was a great demand for a product of this sort.

It is a curious fact that Mr. Young, like many great discoverers and inventors who have preceded and followed him, conducted the experiments that led up to his patent without any knowledge of the results attained by those who had all but snatched the laurels that are undoubtedly his from his possession. It has been so with such men as Watt, and Roebuck, and Stephenson, and Neilson—all, indeed, whose names are enshrined in the Walhalla of English inventors, have been more or less anticipated in their discoveries. Rankine propounded his theory of the development of heat as one of the forces of thermo-dynamics simultaneously with Professor Clausius of Berlin. Even within the last few years, we find that Danks, to whom the credit of bringing to perfection the rotary puddling furnace has been attributed, just stepped in soon enough to carry off the palm of victory that would otherwise have fallen to Mr. Menelaws of Dowlais, and others who were carrying on experiments in the same direction. There is therefore nothing singular in the fact, that Mr. Young was not the first to attempt the production of paraffin as an article of commercial utility. But it is more strange and worthy of being remembered that he was in entire ignorance of the researches of those who had, in their attainments, approached nearest to the end for which he laboured. Reichenbach, as already indicated, had actually discovered paraffin about the year 1830, and described it to be "a colourless, crystalline solid, fusible by heat, volatile at a high temperature, and remarkable for its indifference to other substances,"—a correct description so far as it goes; while in Dumas' "Traité de Chimie appliquée aux Arts," published in 1835, the practicability of producing paraffin by the distillation of coal was clearly hinted at. Again, Liebig, in his "Familiar Letters on Chemistry," dated 1843, stated that "it would certainly be esteemed one of the greatest discoveries of the age, if any one could succeed in condensing coal gas into a white, dry, solid, odourless substance, portable, and capable of being placed upon a candlestick, and burned in a lamp." When he wrote these words, Liebig had evidently a thoroughly just conception of the form that paraffin should assume, although he was in ignorance of the *modus operandi* by which it could be produced. From the tar of beechwood, in which Reichenbach discovered it, there was no possibility of obtaining paraffin in sufficient quantities to make it an article of commercial value and utility; and the *rationale* of its distillation from coal was as yet unknown, when Mr. Young

applied himself to elucidate this "greatest discovery of the age."

From his own internal consciousness Mr. Young evolved the conclusion that petroleum or its substitute might be produced by the action of heat on the coal, and the vapour going up into the sandstone to be condensed. After carrying on experiments for over two years with only English coal, he became more and more convinced of the practicability of his idea. The results he obtained were very diverse. He had no guide, and he sometimes got one thing and sometimes another. But the ultimate result was, that out of a cannel that came to be mixed with the soda-ash for making the alkali, he got a quantity of liquid that contained paraffin.

At last he had fairly "struck ile," but much remained to be accomplished before his discovery was perfect. In the summer of 1850, Mr. Bartholomew, of the City and Suburban Gas Works, Glasgow—successor of Neilson, who invented the hot-blast—knowing the experiments on which Mr. Young was engaged, showed him specimens of the famous Boghead cannel coal, which is peculiarly rich in paraffin. From the Boghead coal a considerable quantity of paraffin was obtained, and, satisfied at last that he had mastered the problem he had so long sought to solve, Mr. Young took out a patent for his discovery.

From the beginning he was assisted more or less in his experiments by Mr. Meldrum, who had the management of the petroleum works at Alfreton in Derbyshire. At the Edinburgh meeting of the British Association in 1850, Mr. Young and Mr. Meldrum talked over the matter with Mr. Binney, another practical chemist, and eventually these three gentlemen agreed to form a partnership and carry on works for the manufacture of paraffin. Bathgate, in the centre of the Torbane Hill coal-field—a district peculiarly rich in cannel—was selected as the site of the works.

At this time there was not a single establishment in Scotland where paraffin was produced in any form whatever. The shale from which the mineral products which bear Mr. Young's name are evolved was at an alarming discount. In many localities it was thrown out as so much rubbish, as it does not answer so well as other qualities of coal for iron-making purposes. On this account Mr. Young and his partners were able to place highly advantageous contracts for the acquisition of supplies. One of his earliest orders was for 10,000 tons at 12*s.* per ton. Twelve years later it was selling at 30*s.* per ton, and now it is worth from 75*s.* to 90*s.* per ton, or almost as much as pig-iron.

While his patent lasted Mr. Young had all but a monopoly of the paraffin trade, and hence he and his partners were enabled to realize enormous profits. But they were not allowed to enjoy undisturbed possession of the monopoly. Numerous individuals took advantage of the knowledge that paraffin had been known to Reichenbach and others, to dispute the validity of Mr. Young's patent, and one firm after another established works for carrying on its manufacture without regard to Mr. Young's patent rights.

Against these firms Mr. Young felt himself bound to proceed. In 1854 he proceeded against a Manchester firm, who paid him £3,000 expenses, and afterwards purchased a license to work the patent. Again, in 1859, he took action against the Clydesdale Chemical Company, who, after a six days' trial in the Court of Session, before the Lord President and a jury, agreed to an unconditional withdrawal, paying the patentee large royalties in addition to £7,500, on account of damages and costs. Another Scotch firm—Messrs. George Miller and Co., of Glasgow—who were proceeded against, paid £5,000 damages, and acquired a license. Other firms who had meanwhile entered upon this profitable manufacture—for it was the El Dorado of that day—agreed to abide by the judgments passed in Mr. Young's favour, and thenceforth paid him a royalty of threepence per ton of crude oil manufactured. An exception to this rule was furnished by Mr. G. W. Fernie, who had established works at Saltney, near Chester, and against whom Mr. Young accordingly took action in the spring of 1864. This was one of the most memorable trials of its kind on record. Extending over thirty-five days, it engaged the professional services of Mr. Grove, Q. C., Mr. Bovill, Q. C., Mr. Hindmarsh, Q. C., Sir Hugh Cairns, Q. C., Mr. (now Sir John) Karslake, and Mr. Webster, for the plaintiff; while the defendant was represented by the Attorney-General, Sir Fitzroy Kelly, Mr. Chance, Mr. Alston, and Mr. Bruce. The suit was again decided in Mr. Young's favour, and £15,000 were claimed on his behalf for professional expenses, besides the threepence per ton royalty. It is curious to note, that the short-hand writer's bill in this case amounted to nearly £1,000, while the report of the trial occupied no less than one hundred and ninety columns of the *Oil Trade Review*.

We have now to speak of the *modus operandi* of the manufacture of which Mr. Young is the founder.

Commencing *ab origine* with the raw material, which is principally a stone of slaty texture, and a dusky brown colour, we may explain that shale pits are generally worked in juxtaposition with the crude oil manufactories. The shale pits vary in depth from twenty to forty fathoms. The best quality is that which, when cut with a knife, does not splinter, but gives off a continuous shaving, such as would be got from a piece of soap or wax. On reaching the pit bank, the shale is tumbled into a crusher, in passing through which it is ground to pieces, sufficiently small to pass easily down the retorts. The retorts are either vertical or horizontal. Opinions still differ as to the respective merits of these two forms, so that they are both extensively used. The more common retort is a flattened cylinder of cast-iron, about twelve feet long, which contracts towards the ends, both of which are open. The retorts are built in regular rows, their upper ends being fitted with a hopper, the orifice of which can be closed at pleasure, while the lower ends dip two or three inches into a shallow pan filled with water. After the retort has been filled with broken shale, the furnace is brought into operation, so as to raise its middle zone to a low red heat. The process of distillation then goes on continuously. At a temperature of 300 degrees, the hydro-carbons contained in the shale are given off in the shape of gas, which is, to a large extent, condensible. At most of the crude-oil works, the incondensible vapour is collected in a gas-holder, and used for lighting the workshops. The oil obtained from the decomposition of the coals, having assumed the form of vapour, is collected in a large main having connections with the retorts. Through this main the vapour is conveyed to the condensers, which, as a rule, are similar to those used in gas-works. As it passes through the condensers, the vapour is reduced to a liquid form, in which state it is run off into reservoirs, some of which contain as much as 100,000 gallons. These reservoirs are fitted with iron air-tight coverings, for the purpose of restraining the vapour, and preventing its ignition.

Up to this point we have only got crude oil, which is practically useless for commercial purposes until it has been refined. The latter is so much a distinct and independent process, that it does not by any means follow that crude and refined oils are manufactured at the same works. On the contrary, it is only at some of the very largest works where both of the processes are carried on.

On leaving an apparatus called a "separator," in which the two components of oil and water are parted from each other, the process of purification commences by a second distillation. The dark green fluid called crude oil, which at this stage has an appearance not unlike natural rock oil or petroleum, is now pumped into large iron pans, where it is boiled to dryness. In this way, the hydro-carbons are once more driven off in the form of gas, which, when condensed, yields an oil still rather green in colour, but much thinner, lighter, and purer than before. The oil in this state is taken to a set of closed vessels, where it undergoes a sort of scouring process, by being stirred up with sulphuric acid. Run off into a settler, still further purified, it rises to the top, while a black tar, formed by the combination of sulphuric acid with various impurities, subsides to the bottom. Being again similarly treated with caustic soda, the oil is still further refined, previous to being passed on by pumps to undergo a third distillation, which is pursued with vitriol and soda, until it becomes a thin, light, and perfectly colourless fluid. This is paraffin oil.

It is necessary to explain that under the process of distillation, the crude oil yields four different products. The first and most important is, of course, the paraffin oil, for illuminating purposes. Then there is a coarser and thicker oil for lubricating machinery, a volatile and inflammable fluid called naphtha, and paraffin scales. The lubricating oil is that left over from the manufacture of solid paraffin, which is so much a separate process that it might almost belong to quite another branch of the industrial arts. Solid paraffin is obtained from the thicker and heavier oil, of which about twenty gallons are evolved from every hundred gallons of crude oil put through the refining process. The solid paraffin is made by the application of a refrigerating machine, patented by Mr. Kirk, who was formerly manager at the Bathgate works of Mr. Young, and is a brother of Dr. Kirk, of Zanzibar. It is a highly ingenious contrivance, consisting of a piston actuated in a large cylinder by a steam-engine, so as to cause alternate compression and expansion of the air at one end or the other. When under pressure, the air is deprived of its heat by applying a stream of cold water, and on being again allowed to expand, the effect of intense cold is instantaneously produced. The air thus refrigerated is brought to bear on a stream of brine, which it converts into a freezing mixture, thus enabling solid paraffin to be produced in the hottest summer weather. Remaining in solution at a temperature of 60 degrees, paraffin coagulates into the solid form when the temperature is reduced to 32 degrees. Crude solid paraffin is now worth from £30 to £35 per ton.

Paraffin candles, from which a clear, lustrous, and perfectly odourless light is obtained, are made at most of the principal Scotch oil-works. For these candles there is an enormous demand, as their quality is not inferior to that of sperm, while they are much cheaper than that commodity.

Such, briefly, is a description of the processes of manufacture carried on at the paraffin-oil works of Scotland. But there are several collateral branches of manufacture, of not inconsiderable extent that yet remain to be noticed. The first is that of the valuable agricultural commodity called sulphate of ammonia, which is made by the admixture of the water separated from crude oil with sulphuric acid. At all the crude-oil works of Scotland this sulphate of ammonia is produced to a greater or less extent, and as it is worth from £22 to £25 per ton, it becomes a considerable item in the revenues of some of the larger works.

In the pans where the initial step in the second process of distillation takes place, another product is obtained in the shape of charcoal, which is burned in the furnaces ; while the deposit of black tar left as the residue of the process of treating the oil with caustic soda and sulphuric acid, is either used for heating purposes or subjected to analysis with the view of recovering its more valuable components. Thus, the soda-tar is boiled down to dryness, giving off a certain quantity of gas, which is condensed into oil. A black deposit remaining in the still is burned in a furnace so as to get rid of its carbonaceous matter, while the residue, being dissolved in water and boiled down, yields back a considerable part of the soda, which had been used in scouring the oil. The soda, again, to render it caustic, is treated with lime, which is itself converted by this very process into carbonate of lime, the latter substance being again used in the fusion of the waste soda recovered from the soda tar. In fact, the processes carried on in connection with the manufacture of paraffin oil demonstrate some of the most interesting chemical formulæ and supply a *multum in parvo* exposition of the salient principles of that most beautiful and important science.

It now becomes necessary to return to Mr. Young's little venture at Bathgate, and show the wonderful results which it was more or less directly the means of accomplishing.

The Bathgate Chemical Works were originally, as we have indicated, of very limited extent, but the manufacture, in Mr. Young's hands, became both successful and profitable in the highest degree, so that he was soon able to extend their ramifications. In the month of October, 1864, Mr. Young's patent rights expired, and the partnership between the patentee and Messrs. Meldrum and Binney, which was co-extensive with the duration of those rights, also came to an end. In the same month, therefore, the Bathgate Works were brought to the hammer in Edinburgh,—the upset price for the land (25 acres), buildings and plant being fixed at £50,000 ; but no one was bold enough to offer that sum. Two years later, however, the works were transferred to a limited-liability company at the price of £450,000,—Mr. Young having himself carried them on and greatly extended them in the interim. The new concern adopted the name of "Young's Paraffin Light and Mineral Oil Company," Mr. Young taking stock in it to the amount of one fourth. For some time afterwards, he continued to act as general manager of the company, which has since enjoyed upon the whole, a tolerably prosperous career.

Meanwhile, Mr. Young had projected another large establishment at West Calder, as an auxiliary to the Bathgate Works. West Calder is a village almost midway between Glasgow and Edinburgh, on the Caledonian Railway. It was selected by Mr. Young as a site for the Addiewell Works, because of its proximity to a splendid quality, and all but inexhaustible supply of shale suitable for oil-making purposes. Unlike the Bathgate and many other world-famous establishments that have assumed by slow degrees their ultimate colossal proportions, the Addiewell works were originally planned on a very extensive scale. The land leased for their requirements extended to some three or four thousand acres, all containing shale and other minerals ; while some forty acres were set apart for the site of the works. The retort sheds are upwards of 200 yards in length, and each shed contains a double row of retorts. There are altogether close on 400 retorts at these works. This represents a capacity for distilling over 3,000 tons of shale per week, and producing 120,000 gallons of crude oil, yielding 50,000 to 60,000 gallons of burning oil, in addition to about twelve tons of refined paraffin, and a large quantity of lubricating oil. To accomplish these results, the appliances are necessarily on a large scale. The heavy vapours are collected in two underground tanks, each capable of containing 12,000 gallons. Any vapour which does not liquefy in the condensing main is passed through a four-inch cast-iron tubular condenser, which is made up of 1,300 nine-feet lengths, or a course of nearly two and a-quarter miles ! For the purposes of distillation upwards of twenty 2,000-gallon stills made of malleable iron are erected. There is a similarly large number of refining stills, each capable of containing 4,000 gallons. A number of immense store-tanks, each capable of containing 15,000 gallons, are fitted up contiguous to the refining kilns, being so situated that they can collect the oil as it passes from one stage of the refining operations to another. The building in which the various oils are subjected to chemical treatment is four hundred feet in length and eighty feet wide. It has two fire-proof gables, cutting off in the centre the engine-house from which the machinery is actuated. Underneath the roof of this building there are altogether upwards of a hundred large cast-iron vessels, with a capacity varying from 3,000 to 500 gallons. Upwards of 1,000 hands are employed at Addiewell, and in the shale-pits adjoining over 500 miners are at work. One and a-quarter million cubic feet of gas are produced at the works daily. The Addiewell shale yields from thirty to forty gallons of crude oil per ton, of the specific gravity of ·870. We have described the Addiewell works thus minutely because they have furnished a model after which most of the works subsequently erected were built.

From what we have already said, the reader will have gleaned the conclusion that the industry founded by Mr. Young in 1851 has rapidly attained bulk and importance. Probably no other industry now being pursued within the far-reaching limits of the British dominions can point to an equally prosperous and rapid career. Within the comparatively short space of twenty years, the mineral oil trade has attained such a magnitude that it gives employment to over 7,000 workmen, who earn weekly something like £10,000 in wages. At the present time about 800,000 tons of shale oil are annually distilled, producing nearly 30,000,000 gallons of crude oil, while the quantity of refined burning oil obtained from the crude product is close upon 12,000,000 gallons per annum, in addition to solid paraffin, naphtha, and other chemical products.

The Scottish oil manufacture may be divided into four geographical divisions, classified thus—1. Midlothian and Linlithgowshire ; 2. Lanarkshire ; 3. Fifeshire ; and 4. Ayrshire. The largest works are to be found in the Midlothian and Linlithgowshire districts, including Young's Mineral Oil Company's works at Addiewell and Bathgate, the works of Messrs. Meldrum, Simpson, and M'Lagan at Uphall, the Mid Calder Company's works at Oakbank ; the West Calder Oil Company's, the Glasgow Oil Company's, and the Bathville works. In the Lanarkshire district there are the North British Oil Company's works at Lanark ; the Uddingstone works, the Coatbridge works, and others of less note. The works in Ayrshire and Fifeshire are chiefly of limited extent, and manufacture only the crude oil. Altogether there are now sixty-eight oil-works in Scotland. At eighteen of these works, the crude oil is manufactured and refined ready for the market. At forty others the crude oil alone is made. The great bulk of crude oil is refined at other works in Scotland, but quantities are occasionally sent to the Welsh refiners and to the continent.

But Mr. Young has done something more than simply create a new industry, giving employment to many thousands and providing a livelihood for many thousands more. Although that is certainly no mean achievement, it has in one sense been surpassed by another with which it is identified. Baron Liebeg has defined civilization as economy of power, and there is no better mode of increasing the power of man than by finding out new and hitherto unknown uses for the resources which nature has placed at our disposal. To the promotion of this high end of civilization, Mr. Young has very largely contributed. Until he commenced the manufacture of paraffin oil the material called *shale*, which is obtained more or less abundantly in all coal mines, was almost universally rejected by coalmasters as rubbish. Sometimes it was brought to the surface to be used in the roasting of clay-iron ores, or to be otherwise consumed at the pit-head ; but it was more frequently used underground to fill up the spaces from which the workable coal had been excavated. As soon, however, as Mr. Young began to use it, the previously despised mineral became all at once invested with value and importance. It became the subject of a remarkable case in the Court of Session, known as the "coal or no coal" trial, in which the proprietors of the estate of Torbane hill, near Mr. Young's works, contended that the lessee of his royalties had no right to work it as it was not *coal*, and the right to extract it was therefore not included in the lease. Estates that were known to contain shale rose suddenly and enormously in value. One estate of only limited extent which had been sold a short time previously for only £2,000, became worth £200,000 ! The very poorest qualities of bituminous shale were sold at 8*s.* to 10*s.* per ton. The Torbane hill mineral or Boghead cannel coal, which is the best adapted for distillation, went up from 12*s.* to 70*s.* per ton ! Attempts were made to utilize peat, and it was actually found practicable to obtain from this mineral a merchantable quantity

of paraffin. The Irish Peat Company was started for the distillation of oils and obtained from 775 tons of peat in addition to the residue of charcoal—

Ammonia	1 ton 4 cwt. 1 qr.
Naphtha.....	77½ gallons
Lubricating oils	1,162½ ,,
Paraffin	2,325 lbs.

Although the extraction of paraffin from peat was never pursued to any great extent, it is quite within the range of probability that it may ultimately be obtained in large quantities from that article. Sooner or later the bituminous shales of Scotland must become exhausted, and at the present rate of consumption the time cannot be very remote. To enable peat to be utilized profitably it is only necessary to charge a trifle more per gallon for the oil. This part of our subject is at any rate one well worth consideration, for the peat of Ireland alone is estimated at 3,000,000 acres, having a weight when dry of 4,000,000,000 tons, and a value of over £1,000,000,000 as fuel. It would be a good thing for poor Ireland if her peat could be utilized in this profitable manufacture.

For a number of years after the paraffin-oil trade had been undertaken by Mr. Young, and while it was limited to his works and to those of Mr. Fernie at Saltney, immense quantities of petroleum were imported to this country from America and elsewhere. But of late years, the imports of petroleum have greatly declined, while the exports of home-made oils have enormously increased in extent and value. This is due, primarily, to the discovery of new uses for, and applications of the oil, and to the removal of all legal restrictions affecting its manufacture. But paraffin oil contained within itself the elements that have mainly contributed to its success. Dr. Letheby, of London, one of the greatest authorities of the day, has reported as follows on this product :—

" Careful experiments have been conducted in my laboratory for the purpose of ascertaining the relative combustibility and illuminating power of these oils. These experiments have been made on eight samples of the American oils, known as crystal oil, and five samples of Young's patent paraffin oil. All the samples were obtained from original sources, or were purchased from the principal dealers in the city of London. The American oils were, for the most part, nearly colourless, whereas Young's paraffin oil had a pale amber tint. The specific gravity of the two classes of oils was widely different, for while that of the American oil ranged from 795·3 to 807·2, that of Young's was 830·2. The temperatures at which they evolved inflammable vapour were also remarkably different in the two cases. With one exception, the American oils would take fire at from 105° to 158° Fahrenheit, whereas those of Young would not fire under the temperature of 166° Fahrenheit, and generally not under 175°. The rate at which the oils were consumed in the lamps (which have been expressly constructed for burning the oils) was as follows :—The American oil burnt at an average rate of 289 grains per hour, and gave the light of 4·98 sperm candles of standard quality, whereas Young's paraffin oil burnt at an average rate of 265 grains per hour, and gave the light of 5·52 sperm candles. It is manifest from this that the durability of combustion and the illuminating power of Young's oil are considerably greater than the American oil. In fact, one gallon of Young's oil will burn for nearly 221 hours, whereas one gallon of the American oil will burn for only 194 hours. Considering also that the illuminating power of Young's oil, at this rate of combustion, is equal to 5·52 sperm candles, while that of the American is only 4·98 sperm candles, it is evident that, for the same amount of light, one gallon of Young's oil is equal to rather more than one gallon and a-quarter of the American oil."

Before taking leave of the "Scottish Petrolia," as it has been not inaptly termed, it may be well to take a glance at the future prospects of the mineral-oil industry. The extreme competition which has sprung up within recent years, necessarily compels manufacturers to sell at the lowest possible profit. They have the whole world for a market. Petroleum is the only product with which paraffin comes into competition, and the latter is now sold at almost the same price as the former. Being the better article of the two, paraffin is therefore bound to run a winning race. If prohibitory duties are not imposed upon its import into foreign countries, it will certainly find an ever-widening demand. Already it may be found in almost all parts of all the four quarters of the globe. One of Mr. Young's favourite stories relates to a voyage up the Mediterranean in his fine yacht, some years ago, when he found "Young's paraffin oil" vended in the most barbarous and out-of-way localities, where no other commodity of British manufacture appeared to penetrate. He and his *compagnons de voyage* every now and again made up their minds that at their next port of debarkation, they would discover paraffin to be an unknown blessing; but over and over again they found themselves mistaken. Paraffin has, in fact, become a great power, although only yet in its infancy. So far as the future is concerned, Scotland, the home of the paraffin trade, has every reason to take courage. The whole country, between the Forth and the Clyde, is peculiarly rich in bituminous shales, so that there is an amplitude of raw material at hand. Although the shale is found at all depths between the surface and the silurian or lowest fossiliferous strata, it is in many cases obtainable in open cast or surface working, without mining. Many people, eager to be rich, have lately gone into the mineral-oil trade, satisfied that its prospects are at least equal to that of any other industry. Within the last year or two there has been an enormous expansion of the trade, several of the older-established works having been transferred to limited-liability companies, by whom they have been largely extended.

It is unhappily only too seldom that the pioneers of progress and civilization—the inventors and discoverers who have chiefly benefited mankind—have lived, as Mr. Young has done, to benefit themselves, and reap the rich and abundant harvest that they have sown. In less than twenty years' time Mr. Young was enabled to accumulate a fortune sufficient to buy up a dozen rich men, and yet leave himself far from poor. He has seen a splendid outcome of his labours. He stands alone in his day and generation as the founder of an entirely new industry, involving the attainment of such wonderful results. It is claimed, indeed, for the little factory which he set up, that it is the parent, not only of the mineral-oil trade of Scotland, but also of that of America, for oil had never been distilled to produce an article of commerce until he commenced to work his patent.

Although Mr. Young has not been directly engaged in business for the last six or eight years, he has never failed to bestow a great part of his time in furtherance of the interests of his favourite science. In connection with his beautiful mansion at Wemyss Bay, on the Forth of Clyde, he carries on a chemical laboratory, in which he is daily to be found when at home. Only within the last two years he has given to the world an exceedingly beautiful invention for the more economical manufacture of soda. Over 200,000 tons of carbonate of soda are annually produced in Great Britain at an estimated value of £2,000,000. This chemical is largely used for domestic purposes, as every housewife knows; while in the manufacture of soap and glass, in dye-works, in bleach-fields, and in other branches of industry, it is more or less absolutely necessary. Carbonate of soda is principally manufactured in South Lancashire, but on the Clyde and the Tyne there are also large works engaged in its production. It is obviously, therefore, an industry of no mean importance; and an invention calculated to cheapen the cost of its production can only be hailed as a public boon. Such an invention is that which Mr. Young has just found out; its merits are such that it is expected to introduce quite a revolution in the great alkali manufactures of the world.

In a magazine intended for practical and scientific men, it may be well to give a technical description of Mr. Young's process. In the manufacture of soda, as now carried on, the first step is that of heating common salt and sulphuric acid together, when hydrochloric acid and salt cake or Glauber's salts are produced. The next process consists in roasting this salt cake with chalk and coal; when sodium carbonate is formed and separated from the impurities mixed with it, by the ease with which it dissolves in water, the other substances remaining unaffected. Mr. Young adopts an entirely different mode of treatment. The principal chemical re-actions of his system take plaee in two large revolving cylinders. In the first cylinder a charge of common salt is placed, and a quantity of water is thrown over it. To this solution ammonia is added. The cylinder is then caused to rotate so that large surfaces of the mixture may be exposed, and carbonic-acid gas is introduced. The solution absorbs this gas, is poured over it until absorption ceases, or till it becomes quite saturated. An important chemical change thus takes place, the sodium of the salt becoming united with the carbonic-acid gas and hydrogen, thus forming carbonate of soda (baking powder) and the ammonia, joining with the chlorine of the salt, forms sal ammoniac. A white powder has now been precipitated to the bottom of the solution. The liquid sal ammoniac is drawn off, and this white powder is found to be bicarbonate of soda. A small quantity of water having been poured over this white powder to cleanse it, it is placed in the second cylinder, which is set over a furnace and made to revolve rapidly. Steam jets are now allowed to play upon the contents, thus throwing off the excess of carbonic-acid gas held in the powder. After this process has ceased and the contents of the cylinder have evaporated, pure carbonate of soda is left in the vessel. So far so good; but Mr. Young has always aimed at the utilization of secondary products; and he supplements this exceedingly simple process by drawing off the sal

ammoniac found in the first cylinder, and on mixing it with lime and exposing it to a high temperature he re-forms pure ammonia. Led back into another charge of salt and water in cylinder No. 1 this ammonia plays its part in the transformation over again. As for the excess of carbonic-acid gas, which was contained in and expelled from the bicarbonate of soda, it is carried through pipes to repeat its part in the original process. It is expected that by this new system of manufacture, carbonate of soda will be produced at something like one-fourth of its present cost; and should it realize all the expectations formed concerning it, there cannot be a doubt that it will secure for its inventor a meed of fame and fortune scarcely less than that which has accrued from his discovery of paraffin. For more than two years Mr. Young was employed in the perfecting and development of this process, and now that it has been made known to the world, he has taken care to obtain protecting patents both at home and abroad. Indeed nearly all the Governments of Europe have allowed his patent rights. Mr. Young himself has advanced too far into the "sere and yellow leaf," to work this patent as he did his former one, nor has he the same motive to do so, but his eldest son has in view the erection of works where it will be put into operation.

Mr. Young's name is associated with another important discovery of quite a different kind from either of those already alluded to. In January of 1871, his attention was called to the rusting of iron vessels by observing that the bilge-water of his yacht (the "Nyanza") was much discoloured by red oxide. Knowing that bilge-water is apt to become acid and thus attack iron, he could easily account for this result, and as he himself pointed out in a paper "On the Preservation of Iron Ships," which he read before the Royal Society of Edinburgh in the Session of 1871-2: "Even when the water does not become acid, we may expect some action on the iron to take place when sulphuretted hydrogen exists, as it frequently does there, as in that case, first a sulphide, and then an oxide with some sulphate, are formed." The remedy appeared to Mr. Young to be easy of application, because the acid could be neutralized by lime, which would also prevent the formation of sulphuretted hydrogen. He therefore put this remedy into operation, adding lime until the bilge-water was alkaline, and samples, taken every fourteen days, showed the amount of rust to be rapidly diminishing. After six months, the liquid became perfectly clear, so that the cure was complete. Mr. Young's yacht is a composite one, and the action upon it was therefore greater than upon iron vessels generally, because of the use of copper or cupreous bolts, which cause galvanic currents with the iron, and greatly assist in its oxidation and solution. As a little lime will last a long time, Mr. Young's remedy involves neither trouble nor expense; and seeing that the loss of the "Megæra" and other vessels has been attributed to the action of bilge-water, his discovery cannot fail to be regarded as an important acquisition to nautical science.

Of Mr. Young's more personal history we have left ourselves little room to speak; but this is the less to be regretted as his has been essentially a scientific career. Eschewing the excitement of politics and the amenities of fashionable life, he has from first to last "scorned delights and lived laborious days" in the pursuit of the hidden mysteries which chemistry is ever and anon unfolding. He never even courted municipal honours, parochial dignities not being in all his thoughts. For a number of years past he has held the office of President of the Andersonian University in Glasgow. It is a laudable ambition that led him to aspire after the highest office in that very institution where he was at one time one of the humblest scholars and afterwards a class assistant. Climbing the rungs of the ladder of fame steadily and laboriously, it is doubtful whether he ever looked forward to attaining such an elevation as this. It was at any rate a long way to look up; but now that he has reached the top, there are none who grudge him the honours he has so well earned,—none question his fitness for the exalted position he occupies. Throughout his whole life indeed Mr. Young has cherished a peculiar affection for his *alma mater*. Less known, less celebrated, and more within the range of poor scholars than the Universities of Glasgow or Edinburgh, the Andersonian was yet to Mr. Young all that these two celebrated seats of learning have been to their most distinguished *alumni*, and something more; for it provided him with a means of earning his livelihood while he was yet sitting at the feet of the scientific Gamaliel of that day. Mr. Young has not forgotten what he owes to the Andersonian, but, on the contrary, has nobly repaid his obligations and exhibited his gratitude by bequeathing on its behalf a sum of £10,000 for the foundation of a Chair of Technical Chemistry, intended to supply the only link wanting to make the Andersonian one of the first chemical schools in the kingdom, by establishing a connection between the scientific chemist and the workshop. This bequest provides for the foundation of nine bursaries, each worth £50 per annum, thus holding out inducements of the most valuable and tempting kind to poor students who might not otherwise be enabled to qualify themselves for the pursuit of a science which is yet only in its infancy, and in which they may ultimately make discoveries that will "witch the world," and benefit humanity.

Living such a busy, studious and secluded life as he has done, Mr. Young has had little opportunity to cultivate on anything like a large scale the amenities of personal friendship. His circle of intimate friends is therefore limited in extent, but it embraces not a few of the most eminent men of the day. Between Dr. Lyon Playfair and himself there has always existed a peculiarly close intimacy. Dr. Livingstone, the well-known African traveller, is also one of his oldest and most cherished friends—their intimacy having commenced when they were fellow-students at the Andersonian University in Glasgow, while it has continued unbroken ever since. It is, therefore, accordant with the fitness of things that Dr. Livingstone should have laid the foundation-stone of Mr. Young's new works at Zanzibar, and that Mr. Young should himself have organized an expedition some years ago in search of the great explorer when his fate was still a mystery.

Little remains to be told. Surrounded by the members of his own family, and by those of his friend Livingstone—for he has really been *in loco parentis* to the children of the African traveller—Mr. Young now spends the great bulk of his time at his beautiful estate of Kelly, near Greenock, or at his no less fine and romantic estate of Durris in Aberdeenshire. But he also mixes to some little extent in public life, contributing liberally to all movements of a patriotic or charitable character, and aiding by every means within his power the progress of scientific knowledge. One of his most recent public acts was the erection of a monument in George Square, Glasgow, to his life-long and constant friend, Dr. Graham, Master of the Mint. It is a capital representation of the great chemist, and is worthy to keep company with the statues of Scott, and Campbell, and Watt, and Moore, and Peel—the noble creations of Chantrey and Flaxman—by which St. Mungo's Walhalla is adorned. It is interesting to note that the erection of Professor Graham's monument by Mr. Young supplied the occasion for a shilling subscription towards a monument for Robert Burns, to whose memory the citizens of Glasgow had not previously paid this form of tribute. The movement has been a great success—upwards of £1,500 having already been subscribed—*all in shillings*—towards its praiseworthy object.

JAS. S. JEANS.

THE DEMIDOFFS AND THE MINING INDUSTRY OF THE URAL.

THE development of the Russian production of gold, and mining industry of the empire of the Czar, is of modern origin, and it dates from Peter the Great. This ruler knew how to choose the fittest instruments for the execution of his plans, and thus it was the Demidoff family became for ever connected with the mining industry of the Ural. Whilst the colossal fortunes of many of the Russian nobility have no very honourable origin, the riches of the Demidoffs flow from the purest source, industrial enterprise. Demid Grigoriewitsch Antufeeff, a crown-peasant of Pawtschino, removed in the seventeenth century with his brothers to the governmental town of Tula, to the south of Moscow, where the descendants of the latter, the Antufeeffs are still to be found among the smaller citizens. When old Demid died, in 1690, he left to his son a well-established manufacture of arms, and a handsome capital, which certainly appears small compared with the present wealth of the Demidoffs, but yet was its foundation. Four years afterwards, Peter the Great came to Tula. In his suite was young Schafiroff, a passionate sportsman and a crack shot, who, wanting some repairs done to a pistol made by a then famous German maker, was recommended to go to Nitika Antufeeff. The latter was told to take plenty of time, but to do the repairs well. But in a few days he brought it back already, and Schafiroff, having closely examined his favourite weapon, expressed to the gunsmith his great satisfaction at the manner in which he had repaired it. But Antufeeff begged his pardon for having been unable to repair it, as it was too old, and having instead made an entirely new one. "What!" exclaimed Schafiroff in a rage, "you peasant pretend having made this pistol?" Humbly Antufeeff drew from his pocket a second

pistol, saying, "Sir, here is the old pistol." Schafiroff was greatly surprised, at last he grew convinced of the fact, and informed the czar of the existence of this clever artist. Peter, who always put the right man in the right place, appreciated him as we shall see presently.

Soon after, during the war with Turkey, in 1696, the gunsmiths of Tula were called upon to supply arms. With many others of his guild Nitika also appeared before the czar. When Peter saw the fine form of the young man, he observed that he would look well in the uniform of the guards—words which then were almost tantamount to a command. Nitika threw himself at the feet of the czar, and begged to be spared, as he was the only son of his aged mother. "Have no fear," said the czar, "make me 300 halberds, as good as this pattern, and bring them to me at Voronesch." "I shall make them better," Nitika proudly replied, and kept his word. Peter paid him more than agreed upon, and moreover, made him a present of a silver cup and a German cloth for a suit.

On his return, after the close of the campaign, in consequence of which Azof had to be ceded in 1699 to Russia, whereby the emperor had attained his favourite wish of getting a footing on the Black Sea, Peter stopped at Tula. The gunsmith Nitika was highly delighted when he saw the czar enter his house, and heard from his own mouth how satisfied he was with the arms he had supplied. Nitika now begged of the emperor to be allowed to offer him a glass of malmsey wine. But Peter haughtily inquired how such a simple workman dared drink such costly wine. Nitika humbly replied that he had merely provided it for his majesty, since the emperor had promised to visit him; he and his wife were satisfied with Russian brandy and mead. "That's right," replied the pacified emperor, "your wife shall bring me what both of you drink." And the emperor so enjoyed his draught, that he gave a hearty smack to the gunsmith's wife. Those who know how the czar kissed the princesses at German courts will not be surprised at his doing so where a subject only was concerned.

From that time, Nitika was in such favour with the emperor, that when a son was born to Nitika, Peter gave him, in 1701, a large piece of land in the forest of Milonoff, near Tula, where there were rich strata of ore, for the erection of a factory. Nitika continued to supply cheap and good arms for the army, which so pleased the czar that he sent for him to Moscow. There he appeared with his little son in a peasant's garb, but was nevertheless admitted to the imperial table and obtained the ironworks of Nevianska on condition of always supplying good and cheap arms; he moreover, was granted the right of shoading for copper in the Ural mountains, whilst the silver mines he might discover should belong to the State. Peter, moreover, gave him large estates with numerous serfs, conferred on him nobility for life under the name of Demidoff assumed by his father, and in 1720 invested him with hereditary nobility. Nitika with a number of workmen and miners traversed the wilds of the Ural, and following the water courses, penetrated deeper and deeper into the interior of the mighty chain. It was during one of these journeys that his wife bore to him in the midst of a mountainous region, far from all civilization, in the neighbourhood of the modern Kajeka on the Tschussowaia, his second son Grigory, whose place of birth was afterwards indicated by a simple cross. The great mines of Schuralinsk, Werchne-Tagilsk, and Nischne-Tagilsk were gradually opened by the former gunsmith, who died in November, 1725. The first workmen who worked in the mines and ironworks of the Ural, had been carried thither from the Turkish frontier, at the emperor's command. The Demidoffs naturally gave their chief attention to the production of iron, but this did not prevent them from promoting other useful objects. Thus they rendered the Tschussowaia navigable, and established good roads, and did as much for the colonization of the country as the Strogonoffs; in fact, it may be asserted that the Demidoffs and the Strogonoffs Russianized the Ural. It was these two families that gained this country for the czar, by conquest and industrial pursuits.

But the Demidoffs did not confine their operations to the Ural; they re-opened old ironworks on the Irtysch, and in 1725 penetrated to the lake Kolivan. Their manner of working, however, was very rude and primitive, and it was not till 1744, when several Germans were sent to examine the works on lake Kolivan and the river Oc, that the ironworks were fully developed. A short time previous, the Demidoffs had discovered gold and silver in the neighbourhood of Barnaul, which, according to law, however, belonged to the crown. The gold and silver mines were placed under the direction of Beier, a German, who had been sent by the Russian Government to inspect them, but the grand ironworks, as well as the gold mines discovered later on in the Ural, remained in the possession of the Demidoffs.

In this manner a whole super and subterranean world, with all its treasures, became the possession of the gunsmith of Tula, and since then his descendants have attained to incalculable wealth. The ever-rising family, highly favoured by fortune, soon found itself at home in the honours conferred on it. In 1812, when Napoleon invaded Russia, the head of the Demidoffs, Count Nikolai was able at his sole expense to raise a regiment for the defence of his country, and to conduct it to Paris. And what is greatly to the honour of the Demidoffs, when they had attained their high rank and great wealth, they did not give themselves up to luxurious idleness, but did their utmost for the promotion of science, art, and industry. Prokop Demidoff—in other respects one of the most eccentric characters of his day, that is to say, he had the courage to think for himself, and to despise what the fashion-worshipping world calls common-sense, which, as a rule, means no sense at all—gave the princely sum of 1,100,000 roubles for the foundation of the Moscow Orphan Asylum. Count Nikolai Demidoff, who had led the regiment raised at his own cost to Paris, after the peace did not like to leave the French capital again, but settled there, chiefly with a view of procuring his son Anatol, born in 1813, the present head of the house of Demidoff, a distinguished education. Afterwards Count Nikolai went to Florence, where he built the splendid villa of San Donato, which he filled with treasures of art. He also founded a school for the poor at Florence, after having done the same for Moscow and Petersburg.

The present head of the family, Prince Anatol Nikolajewitsch Demidoff, Count of San Donato, and lord of the manor of Nischnei-Tagilsk, who, as we have seen, was educated in Paris, in his eighteenth year returned to Russia, to undertake, after his father's death, the management of his enormous estates. The use he made of his riches showed his goodness of heart and sound sense. At Petersburg he purchased a large building and dedicated it to charitable purposes; 200,000 meals are annually distributed in it to the poor, 150 destitute boys and girls, women of the better as well as the lower classes are maintained therein, and it also contains a refuge for the protection of girls under sixteen. When the cholera devastated St. Petersburg he erected a large hospital, and exposed himself to personal risk in visiting the sick.

The central point of the prince's extensive operations is Ni-tag, in the Ural, where he maintains a large number of supervisors, inspectors, miners, workmen, clerks, and so on. His favourite residence, however, is his estate of San Donato. The grand duke of Tuscany having made him Count of San Donato, he married, in 1841, the daughter of Jerome Napoleon, late King of Westphalia, and son-in-law of Frederick, King of Wurtemburg. By this union the Demidoffs became related to the emperors of France and Russia. But the marriage was not fortunate; dispositions did not agree, and after four years it was dissolved.

But San Donato remained a temple of the muses, and its treasures, collected under the directions of good taste, must be seen to be appreciated. In spite of his predilection for art, however, the prince neglects not the interests of science and industry, and frequently visits his large works in Russia. The industrial institution of Florence has been particularly promoted by him. In 1842 he sent the director for six months to visit the schools of art and industry at Lyons, Paris, Versailles, London, Stockport, Edinburgh, Glasgow, Brussels, Geneva, Lausanne, etc. Since then the grand Demidoff institution at Florence has been so enlarged that not only a large number of poor children receive primary instruction, but a number of young men receive a more advanced education; opportunities are afforded to them to learn spinning and weaving, or other trades for which they show aptitude. In a particular wing of the institution there are laboratories, as well as industrial schools for silk-weaving, printing, bookbinding, shoemaking, &c. Prince Anatol takes a lively interest in the progress of science; mineralogy, geognosy and geography, are naturally those branches that engage his attention most. Every year he sends eight young men to travel and educate themselves into architects, mining and iron-work managers. When, in those parts of Russia where wood is scarce, the want of coal became greatly felt, the prince organized an exploring expedition, which he conducted personally, and the results of which were published in four large volumes in 1842, which have been translated into most languages. The prince is a member of many learned societies; in his outward appearance bears, it is said, a great resemblance to Peter the Great, and, like him, detests etiquette, flattery, and sham.

"By their fruits ye shall know them." This axiom also applies to the Demidoffs. This family will only, then, be fully appreciated when we follow them to the theatre of their activity, the Ural, and see what they have created there within a century and a-half. We may at the same time cast a glance at the metal production of Russia, so important to that country, and which owes its origin to the Demidoffs. Its main seat is still the Ural, which in these days of rapid locomotion is no longer a far-distant region. Railways will take us as far as Nishni-

Novgorod on the Volga ; thence we may reach the mountain-chain separating Europe from Asia, partly by water down the Volga, and partly on the light *tarantasse* or on sledges by way of Kasan and Perm.

Though the Ural descends to southern latitudes, its climate yet is severe and wintry, especially in the northern parts of the chain. According to the opinion of the ancients gold could not "thrive" there ; but let us examine the reality.

The gold-fields stretch almost through the whole of Siberia to the Japanese seas, to shake hands, as it were, with the western coasts of America. Everywhere in those regions gold is found by washing or mining. As regards the Ural those valleys especially are rich in gold where, under a cover of peat, a dark-red clay is found ; and the inhabitants maintain, not without a show of reason, that that red clay, which clings to the wheels of their mountain carts, always contains particles of gold. The Russian government possesses four gold-mines in the Ural—the first opened in 1754, which, up to the end of 1864, had yielded 5,608 poods of 40 lbs. each. Thirteen mines belong to private owners, and had yielded since their opening—the first having been in operation since 1819—6,710 poods. Towards the south, in which direction Russia is ever extending its direction, we encounter gold again in various districts, as well as in the Altai mountains, whence it is carried six times a year by large caravans to St. Petersburg, which they reach after a two months' journey.

We are familiar with gold-digging in warm climates, but the search after the yellow metal amidst ice and snow seems strange ; and yet it is a fact. The mines reach up to the 67th degree of northern latitude ; and in the Jenisseisk government, in a region almost as cold, lies the centre of all the gold-mining of eastern Siberia. But there the produce is greatly lessened by unsuitable and defective mining laws, and the greatest obstacle to free development is the fact that all gold must be handed over to the State. It is true, before the discovery of gold there was scarcely any life in eastern Siberia, irrespective of the trade with Chinese, which was carried on by way of the one station of Kiachta, and the trapping of wild animals for their fur. But the gold discoveries produced a total change, and the Siberian virgin-forest, the Taiga, was traversed in every direction. With hundreds of workmen the contractors penetrate into the almost inaccessible mountains, dense forests or tundras, where they turn up the peat, not seldom up to their loins in water or snow. We meet with them in rocky labyrinths and forest solitudes, bearing every kind of privation, and sparing neither health nor life. The same gourmands, who a few months ago at Jenisseisk or Tomsk fared sumptuously on truffles and champaign, now satisfy their hunger with a soup perhaps prepared with the leather of an old pair of boots. The follies committed by these people are incredible. A man possessing one of the most productive *prüsks*—gold-yielding vein—one day found a lump of gold weighing eleven pounds ; he then threw himself at full length into the mud, and ordered his servant to pour champaign over him, crying at the same time : "Pour on, Jack ; I'll make you a nobleman." A workman at Jenisseisk paid some hundred roubles for a piece of silk, and had it laid down on the ground lest he should soil his boots. Only the mad doings of our own sailors in the days of plentiful prize can be compared with it. The houses of those successful gold-diggers resembled hotels, where all who would drink and gamble were welcome. Playing at cards was the rule, and as much as 45,000 roubles were staked on a single card ; no other wine but champaign was tolerated.

The consumption of articles of industry and luxury increased with the discoveries of gold. In the small towns, which rapidly grew into large settlements, continual fairs were held, and the sale of agricultural and industrial products rose from 700,000 roubles to ten millions. How much, however, an industry, fostered by gold-digging leaves to be desired may be inferred from the fact, that as late as 1860, there was no steam-engine in Western and Eastern Siberia, while the private miners had only one. The greatness and importance of the gold production of European and Asiatic Russia—after North America and Australia, Russia is the *third gold land* of the globe—is shown by the circumstance that from 1820 to 1860, that is to say, in forty years, the State received sixty-seven millions of roubles in duty on private mines. The total amount of gold produced from 1814 to 1860, was 35,487 poods. The year 1857 was the most successful, the find having amounted to 1,733 poods, whilst in 1820 it was only 19 poods. Since 1850 the average production has been 1,450 poods.

Having spoken of the noblest metal found in the Ural mountains first, we must not pass over its other mineral treasures. Over a superficies of more than 100,000 square miles, its soil is impregnated to a great depth with copper, whilst iron and lead, copper, silver, gold and platina are found here and there, together with the rarest gems, diamonds and rubies, topazes, sapphires, calcedonii and agates of uncommon size.

Iron and platina, the eldest and youngest ores drawn from the Ural, deserve special mention here ; the former on account of the plenty in which it is found ; the latter because of its intrinsic value.

The first ironworks in the central Ural were established in 1623, seventeen years after the first copper-works. The riches of the soil became more and more apparent, large lumps being frequently found, the largest being that discovered in 1772 by the daring traveller and naturalist Pallas, weighing 1,600 pounds. Industry and perseverance met with their reward. The State and private speculators turned with successful activity to this new field of enterprise, so that in 1830, in spite of the difficulties of the ground, there were already ninety works in operation in those regions. From that time the production of iron was rapidly developed, and in 1838 no less than 8,320,000 poods, equal to 2,773,000 cwts. of cast-iron, and 7,495,000 poods, equal to 2,498,000 cwts. of wrought-iron ; and in 1850 about 10,000,000 cwts. of iron, cast and wrought, were despatched from about 500 furnaces, employing some 20,000 workmen.

The find of platina (*i. e.*, "small silver") was not so plentiful, but its intrinsic value, superior to that of silver, and almost equal to that of gold, nearly balanced that of the much larger supply of iron. Platina was first discovered in 1736 on the river Pinto in Peru, and for nearly a century reached us only from Borneo, Brazil, New Grenada and St. Domingo, where it was found in the sand in small flat grains, mixed with gold and magnetic iron ore. In 1819 it was also discovered in the gold-washings on the Asiatic side of the Ural. Pure platina is white, but less shining than silver, harder than copper, and after gold the most ductile material. The rulers of the Russian empire therefore conceived the idea of employing platina for coins, and until 1845 the large sum of 8,186,620 roubles of platina money were coined. But the rapid wear of these coins soon showed the mistake, so that in the above-named year all platina mints were closed, a step which was also followed by the shutting up of many platina washings. But from that time science and industry turned all the more to the winning of that metal, which is so much in request on account of its resistance to melting, and indestructibility by most re-agents, and is largely employed in chemical and philosophical apparatus, such as crucibles, retorts, telescopic mirrors, points of lightning conductors, &c.

Having at first been found only in grains and small pieces, a lump weighing three and a-half pounds, and found in South America, excited general astonishment ; but it was soon eclipsed by a piece found in the Ural, and weighing twenty pounds. Between 1850-52 Russia supplied annually more than 3,000 pounds of this metal. Its total supply to commerce, since platina was first found, has been 678 cwts.

The central and most important point, after Jekaterinburg, of the entire mining district of the Ural, is the market-town of Nijni Tagilsk, founded in 1725 by Akinfij Demidoff, which in 1864 contained no less than 28,133 inhabitants, including 260 traders. Nijni Tagilsk embraces 221 industrial establishments, 326 houses of business, 132 hotels and restaurants, and lately a splendid goods depôt has been erected in the centre of the town. We mention these data to indicate the rise of a Siberian town ; for though it officially belongs to the government of Perm in Europe, it yet lies on the eastern declivity of the Ural, and therefore geographically in Siberia. It is a place of great commercial activity, and the works belonging to it produced in 1864 906,000 poods of iron, 101,448 poods of copper, and 9,593 poods of steel ; also thirty poods of gold. Since 1865 platina was obtained, and it was expected that the first year would yield 100 poods of the precious metal.

Platina, like gold, is found in alluvial soil, in narrow valleys, sometimes traversed by small streams. The bottom of such valleys is filled with sand and grit, especially serpentine and chlorite-slate. These are washed either on plain wooden wash floors, or by means of centrifugal machines, which separate the heavier metal from the dross. Gold and platina occur principally in the form of small grains ; only in rare instances larger pieces are found. But the platina is never quite pure and free from foreign admixtures of peculiar metals, known as platina-metals, which chemistry turns to account.

A layer of copper-ore found in 1812 between magnet hills, in the neighbourhood of Tagilsk, is very interesting. It has an elliptical form, is about 1,800 feet wide, 290 feet long, with a depth of about 500 feet. This ore is the beautiful malachite, the pieces as a rule are small, but there are larger ones. The splendid columns of the Isaac's church at St. Petersburg came from this quarry. One piece was discovered weighing 720 cwts., and worth about 1,200,000 dollars. Within forty-seven years more than 103 million poods of ore were obtained from this layer, which yielded more than 3,600,000 poods of pure copper.

The ores of these mountains are worked up in foundries, sheet-iron forges, stamping-presses, &c., and their products rival

those of our own country. Sheet-iron, as thin as foreign letter-paper, and which may be rolled up like copper sheeting without breaking, is one of them. Beautiful cast-iron and stamped goods of elegant design come from those works. Prince Anatol Demidoff every year sends intelligent young men to foreign countries to be educated at his expense, so that even in matters of taste the products of his establishments may not be inferior to others. The varnishing of block-tin is so well understood as to rival Japanese and Chinese work of this kind; it has the further advantage of resisting heat.

Prince Demidoff possesses more than 200 (German) square miles of forest. To maintain the forges and furnaces always at work these forests are divided into cuttings of from sixty to eighty years, and placed under the care of experienced officers. Whole villages of former serfs have undertaken to supply coal regularly. Every man has to deliver annually 100 baskets of 20 poods each.

Besides Nijni Tagilsk, the ancient works of Newiansk, where the Demidoffs first established themselves, are still a chief seat of the mining industry of the Ural. Newiansk, which now numbers about 11,000 inhabitants, was founded in 1700 by Nitika Demidoff, and the old castle with its curious decorations and antiquated internal ornaments reminds one of those times when the influence of Dutch taste asserted itself in the empire of the czars.

From the walls of the drawing-room the portraits of the Demidoffs in their old-fashioned costumes look down upon the iron furniture around. But before the astonished guests stands a table loaded with game, Burgundian and Rhenish wines, Madeira, champagne and similar delicacies; it is an ancient custom thus to treat every traveller visiting the castle, close to which stands a large tower of brick, whose foundations have sunk, so that it now is a leaning tower. It formerly was a prison, and its entrance subterranean.

Work is not quite so active at Newiansk as at Tagilsk: the iron-ore is procured with great ease. In the neighbourhood there is a layer of red hematite, which is got out by simple quarrying. The nuggets of ore lie in a yellow and green clay, from which they are picked and carried away in baskets or on hand-barrows. The manufacture of grooved rifles is one of the chief occupations here. Large quantities of wood-work are also made here, especially chests which are painted blue and red, and bound with iron lacquered black. These chests are annually sent in large numbers to Siberia, where they form an indispensable piece of furniture in every cottage.

But the most important town in the Ural, the entrepôt of European and Siberian trades, is Jekaterinburg, which numbers 21,000 inhabitants. It contains eight churches, and many of the private houses are so elegant in their appearance, that no European city need be ashamed of them. The town looks particularly pleasing when seen from lake Iset, on which are situated the iron-works of Verchne Isetzkoi, belonging to Count Iakoflef. The Iset river flows through Jekaterinburg, and sets in motion the numerous industrial works erected on its banks. The most interesting of these works are undoubtedly those belonging to the crown, where the valuable stones of the Ural are prepared for use. Here granite, porphyry, malachite, agate, jasper, crystal, amethyst, topaz, &c., are sawn, cut, bored and polished. The Ural in fact is a treasury for the jeweller, and a paradise for the mineralogist. In 1830 a peasant went through the forest near Jekaterinburg, the storm had uprooted a mighty old pine, and behold! between the roots there lay the most magnificent emeralds, glittering in their glorious green. The discovery was inquired into, and a whole quarry of emeralds rewarded the further search. Precious stones like as in nests, in the micaceous schist, and by their side many a cognate mineral treasure, as for instance, the *phenakit*, a new kind of diamond, clear, light-yellow, or pink, which, when polished, is not much inferior to the ordinary diamond. The yellow-green beryls found near Minsk and Nertschinsk are also highly valued.

In 1828 one of these stones was found near Mursinsk, which was 9 inches long and 3 inches thick, and valued at 47,000 dollars. Humboldt, in his travels through the Ural, gave it as his opinion that diamonds might also be found there, and experience has proved that assumption correct. The yellow-brown zirron, which by being passed through fire can be rendered colourless, and when polished may easily be mistaken for a diamond, is found in pieces weighing from $\frac{1}{2}$ to $\frac{3}{4}$ pound. Indeed, to enumerate the precious stones found in the Ural, would be to give a list of almost all the stones ranged under that designation. And the discovery and industrial use of all this wealth Russia owes to the family of Demidoff.

THE SILK INDUSTRIES OF ITALY.

(*From an Italian Correspondent.*)

No. III.

Maleo, *12th May.*

BEFORE the silk is ready for the weaving manufactory we must occupy ourselves with the process of uniting several threads together; for though the silk of, say, $\frac{9}{11}$ den. is immeasurably thicker than the original thread, it is still far too delicate to be worked into stuffs. We need not, however, dwell long on this part of the subject, for in England silk is largely worked—and, indeed, our first machines were manufactured by you. Before and after every process the yarn is weighed, so as to ascertain the loss, and check careless waste. The thread has now to be made continuous by tying the ends together, for the original spinner, when the thread happened to break, did not, for the sake of saving time, pause to re-fasten it, but threw a new end over the asp at once. The room where the transfer is effected presents a pleasing spectacle. Six long rows of tables, a crowd of pretty little faces, a perpetual wagging of little tongues with their "soft bastard Latin," never so sweet and liquid as in childish speech; little hands working very seriously, and little bodies supine on the floor, toying and playing; —for the matrons are indulgent, and while they maintain a proper discipline, do not expect impossibilities from girls of from five to twelve years old. In this room the life-career, that culminates in the spinner, commences, and the tiny childish fingers are taught to handle silk until skill grows up with them like an instinct. I often envy the dexterity and delicate touch of these little fingers, as they find unerringly, but seemingly at random, the uppermost thread of the yarn, and place it on the revolving bobbin, or as they knot together the broken ends.

The yarn is first placed on a lower wheel of very light wood, which turns at the slightest impulse. Above, at about the level of the child's head, the bobbin is inserted in a peg of iron, bearing at one end a screw to secure the bobbin, and at the other a circular piece of wood. Wheels of wood, turned by a common machinery, run all along the benches or tables; and when the bobbin is put on its screw, the circular piece of wood is caught by the adjacent wheel, and the bobbin as it turns takes the silk with it, and by its strain on the silk causes the lower wheel to revolve also.

We have seen how ingeniously the silk is caused to spread on the asp, and the same method is followed to spread it on the bobbins; but the hook is here replaced by a little felt-covered hook, which cleanses the silk on its journey, and prevents the passage of gross impurities. In the constant breakings that occur many little ends of thread remain in the hand, and these are carefully put aside and sold at a high figure; for industrious manufacturers extract stuffs from these waste ends, as we saw that they did from the refuse of the Filanda.

The silk now on the bobbin passes into the hands of older girls, to be transferred to a second bobbin. Bobbin No. 1 is placed upright on the table, and the thread is passed up to a felt-covered hook fastened to a rod above, and parallel to the table; thence it is carried to the revolving bobbin, passing first through two slips of polished steel—something like pincers—which inexorably arrest any knot or dirt still left after the first purification. Before reaching the bobbin the silk is received by a little porcelain spire, which spreads it out evenly, and all day long the girls knot threads, change bobbins, collect ends, and break the monotony of conversation, every now and again, with a merry-chorused song. It has been recognized that girls' tongues must do something, and they are allowed by the matrons to *sing*, and they give themselves leave to *talk*, trusting, rather vainly, that the roar of the bobbins will drown their voices;—rather vainly, because these peasants have lungs unknown to consumption or throat diseases, and when they talk each to the other, it sounds as though a general were shouting to an army.

The silk is now tolerably clean, and can pass to the room where the threads are united—two, three, or more. according to the "title" (thickness) required. One cannot be too careful in purifying silk, for in texture every knot or irregularity is a fault.

In the new room we find again innumerable benches, roaring bobbins, roaring girls (it is but to few that I can apply the word "sing"), and gleaming silk. The steel pincers have disappeared, but the felt hook remains and receives the thread. To each revolving bobbin there are two or three hooks, according to the number of threads to be united; so to each revolving bobbin there are of course two or three upright ones. The threads, passed over their respective hooks, are united into the porcelain

spire and brought on the revolving bobbin. But here and there a thread loosely breaks, and leaves its companion to get along as it best can. This of course would "never do;" human ingenuity supplies the remedy by causing the bobbin to stop when a thread breaks. Thus each thread before going on the bobbin passes through a little hook of wire, which it keeps upright by its own strength, and when the thread breaks the hook falls, raising a small bit of iron to which it is attached; the bobbin has on the screw a little metal flange. When the flange meets the bit of iron the one stops the other, and whilst they enjoy a bit of neighbourly conversation, the girl who attends to ten unruly bobbins fastens the thread, presses the iron, lifts the hook, imprisons the thread, and off they go in company.

"Ah!" you will say, "they are together, these threads; let them be." Not at all. They are parallel, but not united; and they must be united as much as possible. Therefore the bobbin is taken down and placed upright on a peg in another room, which is turned swiftly by a thong of leather. The thread is led up from the upright bobbin, through the usual moving spire, to a large and more slowly-revolving bobbin which gathers up the thread the other one gives off, and the three threads on their passage of more than a yard are by the rapid motion of the little bobbin twisted one around the other. This little bobbin revolves from twenty times and upwards to every one revolution of the larger one, and the more rapid the revolutions the closer of course the twist. A loose twist is called "tram;" a tight one "organzine." The organzine is woven lengthwise, the tram is thrown across; tram is twisted in one direction, organzine both from right to left and left to right. The thread when twisted is placed in a steam bath for a few minutes, so that the gum, melting and spreading in the natural direction of the twist, may, when dry, keep the silk twisted.

The silk is now ready for the manufacturer, and we have only to see how it is taken off the bobbins and neatly packed, and we have done.

The contents of bobbins are unwound on asps turned by machinery, connected with a clockwork similar to that used in the silkrooms. The wheels are of 800 ells to the "strike." The silk is made into reels of two or three strikes, according to its thickness. When the asp is full (ten bobbins are unwound at a time, fresh bobbins being supplied and broken threads tied by girls who attend to this work) it is carried to those whose business it is to give the last touch with skilful scissors; and then the silk, five reels at a time, is twisted as in the silkroom.

About one hundred of these twists are packed together, compressed by a machine similar to a letter-press, and the last touch is given with a delicate iron, with which a well-trained girl combs the twists, as it were, into precise evenness.

Then silk is beautiful to look upon, and the accustomed eye can see, as it were, its softness and strength.

No wonder that where so much care and so much work is required silk should be an object of luxury. For the silk, as I leave it, has yet to be replaced on bobbins, dyed, cleaned, and woven, either by hand or machinery in the usual way, before it can ornament a drawing-room or give additional lustre to proud beauty or haughty pageant.

A. S.

DYE WORKS OF MESSRS. BOUTAREL AND CO., CLICHY-LA-GARENNE.

DYES AND PREPARATIONS ON WOOLLEN STUFFS OR MIXTURES OF WOOL AND SILK:—MERINOS, DOUBLE MERINOS, CLOTHS, SCOTCH CASHMERES, MUSLINS, SATINS, POPLINS, VELVETS, REPS, BOMBAZINES, FLANNELS, SHAWLS, &C.

(*From "Les Grandes Usines,"* BY M. TURGAN.)

WORKSHOP FOR BLACKS.

Colours.	Mordants.	Colouring Matters.
Ordinary black	Hydrochloric acid	Logwood
Blue-black	Sulphate of iron	Yellow wood
Green-black	Sulphate of copper	Turmeric
Very deep black	Bichromate of potass	Sumach
	Bitartrate of potass	

Dye-woods.—Dye-woods are such as contain diverse colouring matters in their cellules. They are grown in certain countries within the torrid zone, and they are delivered in billets weighing about ninety pounds each. To extract the colouring matter the woods are, as has already been mentioned, cut up into chips. The colours are easily extracted by a process of decoction, according to the nature of the wood. They are dark red, light red, yellow, &c.

The principal dye-woods are:—India wood, Brazil wood, and yellow wood. India wood is brought chiefly from Mexico, where it grows in abundance, and comprises logwood, Carmen wood, and Haïti wood. They are very rich in a deep red colour, known as *hématine*. Yellow wood grows in India, the Antilles, and Central America, and is brought from Cuba, Tampico, and Tuspan.

Black.—A compound colour—blue, red, yellow.

Deep Blacks.—Tub-blue, intensified with tartar, sulphate of iron, sulphate of copper, and logwood.

Ordinary Blacks.—These blacks are obtained by previously treating the pieces with mordants—say, with tartar, sulphate of iron and sulphate of copper, or with bichromate of potass, and washing them next day in cold water to remove the uncombined mordant, and prevent its altering the colour bath. To dye them to a sample (blue-black, green-black, or deep black), the pieces, already prepared, are passed through baths containing decoctions of logwood of more or less strength, or decoction of logwood and yellow wood.

The dyeing of black fabrics is one evidence that with the same colouring matter different shades may be obtained by varying the mordants or the acids. For example, *hématine*, a dark red colouring matter from logwood, gives various shades of black according to the mixture, as follows:—

Mixed with.	Resulting shade.
Hydrochloric acid	Yellowish
Sulphuric acid	Greyish yellow
Sulphate of iron	Very deep grey, or slaty
Sulphate of copper	Deep blue grey
Bichromate of potass	Thick blue
Tartar, sulphate of iron and sulphate of copper	Black with blueish reflection.
Sulphate of copper and bichromate of potass	Thick blue-black with reddish reflection
Alumina and tin	Violet
Carbonate of soda	Of a violet colour

WORKSHOP FOR GREENS.

Colours.	Mordants.	Colouring Matters.
Bright greens	Sulphate of alumina	Sulphate of indigo
Dark greens	Sulphate of soda	Carmine of indigo
		Yellow wood
		Picric acid

Indigo.—This blueish colouring matter is brought from tropical countries. It was known to Indian dyers, and was imported into Marseilles in 1728 under the name of Bagdad.

Indigo blue is obtained by macerating and fermenting the leaves of the indigo plant, which are afterwards thoroughly washed, and moulded into tablets and dried. During several centuries this rich blue has been exported to all parts of the world under the various designations derived from the localities from which it has been exported, as indigo of Bengal, of Java, of Surat, of Bombay, of Manilla, of Guatemala, &c.

The following is the average production:—

Bengal, Madras	3,500 tons
Java	550 „
Central America	300 „
Other countries	100 „
Total	4,450 tons
Maximum consumption of all the dye works in the world	4,500 tons

Average price 8*s.* per pound; say, in all, nearly £4,000,000.

The importation of indigo was prohibited in France and England, in the beginning of the seventeenth century; and, thanks to those prohibitions, the Dutch shipowners of the time made immense fortunes. At Amsterdam, indigo, cochineal, dye-woods, and all other colouring matters, were freely imported. Holland became renowned, even in the sixteenth century, for its dyes in black, blue, and scarlet, and England was under the necessity of sending her white cloths to Holland to be dyed and re-exported. It was only in the year 1737 that indigo was freely admitted into France.

Application.—If a deoxidizing salt and an alkali be put into a tub full of indigo and water, the indigo is dissolved, and relapses into the colourless condition in which it is found in the leaves of the indigo tree. Immediately on exposure to the action of the air the blue colour returns.

Sulphate of Indigo.—The blue, or oxidized indigo, insoluble in water, was a colour of no use to the dyer. In 1740, in Saxony, Councillor Barth conceived the idea of reducing it into

a fine powder and macerating it in sulphuric acid, in the proportion of one of pulverized indigo to six of acid, by weight. This composition, soluble in water, is usually applied to wool, but it yields blue-blacks, because of the red, the brown, and the gluten contained in the indigo.

Carmine of Indigo.—Sulphate of indigo, being a mixture of blue, red, and brown, it is necessary, in order to obtain pure blue, to dissolve it in 80 parts of water, and to filter it, then to precipitate it by a solution of sea-salt, to filter it again, and to wash the paste retained by the filter several times. By this process a blue soluble in water is obtained, known as carmine of indigo, or sulpho-indigotate of soda.

Picric Acid.—Carbolic acid, treated by nitric acid, yields a rich yellow colour, called picric acid, which was for the first time employed in dyeing at Lyons, in 1847.

Greens.—The mordant employed for greens is bisulphate of soda. Formerly, the greens were made with yellow wood and carmine of indigo; but since the discovery of picric acid, yellow wood has been replaced by this acid, which yields much brighter greens.

WORKSHOP FOR LIGHT COLOURS.

Colours.	Mordants.	Colouring Matters.
Sky-blue.	Crystallized tartar.	Carmine of indigo.
Grey.	Sulphate of alumina.	Sorrel.
Fancy colours.	Sulphate of soda.	Yellow wood.
		Ammoniacal cochineal.

Sky-blue.—This tint is obtained by a combination of sulpho-indigotate of soda with the fabrics. By adding ammoniacal cochineal to carmine of indigo a great variety of greys are obtained.

Fancy Colours.—These shades may be varied to any extent, and are effected by combinations of red (cochineal or *orseille*), blue (carmine of indigo), and yellow (yellow wood or turmeric). For the application of these colours the mordants are put into the bath at the same time.

WORKSHOP FOR DEEP COLOURS.

Colours.	Mordants.	Colouring Matters.
Bronze.	Tartar.	Logwood.
Aventurine.	Sulphate of alumina.	Sorrel.
Maroon.	Oxymuriate of tin.	Brazil.
Brown.	Carbonate of soda.	Turmeric.
Garnet.		Yellow wood.
		Sulphate of indigo.

Brazil wood is named according to the place from which it is brought—Pernambuco, Saint-Martha, Lima, Bahia. These woods contain a yellow colouring matter, very soluble in water, called *brésiline*.

Turmeric comes from Bengal, Coromandel, and Java. It is the root of a tropical plant, and yields an orange-yellow colouring matter. It is imported as roots, and reduced to powder, and is employed directly in the baths.

Orseille is a remarkable violet-red colour; it is turned by acids into garnet and deep red. This was accidentally discovered in 1300 by a merchant of Florence. He remarked that a fine colour was produced by the application of urine to a species of moss, and after making several attempts he produced *orseille*, and for a long time kept the secret of its manufacture.

Deep Colours.—All these colours are the result of the mixture of various colouring matters (sulphate and carmine of indigo, sorrel, turmeric, yellow wood, Brazil wood, logwood, &c.). The shades can be varied without end, according to the proportions employed.

For the garnets (a simple colour, the red matter of Brazil wood) it is necessary to apply mordants consisting only of tartar and sulphate of alumina, and for the purpose of brightening and varying the garnets, after the dyeing, the pieces are treated with carbonate of soda or with urine.

These various combinations have the effect of fixing on the wool, coloured aluminas or insoluble lacs, which cannot be destroyed by washing in cold water, and which moreover resist the action of air and light.

WORKSHOP FOR FRENCH BLUES.

Colours.	Mordants.	Colouring Matters.
Light blues.	Tartar.	Yellow prussiate of potash.
Dark blues.	Sulphuric acid.	Red cyanide.
	Salt of tin.	Logwood.
	Oxymuriate.	Ammoniacal cochineal.
		Sordane.
		Aniline violet.

Hydrocyanic or prussic acid was discovered, in 1780, by Scheele; and decomposed, in 1814, by Gay-Lussac, when it was found to be a composition of hydrogen and cyanogen. Since 1833, two kinds of prussiate of potass have been employed for blue dyes—the yellow and the red, or double cyanide of iron and of potassium.

Application.—Into a tub containing 400 gallons of water are poured 2¾ drams of red cyanide dissolved in water, 3¼ pounds of salt of tin also dissolved, and 11 pounds of sulphuric acid. The bath is heated to 78° Fah. Ten pieces of 80 metres each are placed in the bath, and caused to rotate, entering and leaving the bath, for five hours.

Before the pieces are placed in the bath the following chemical action takes place:—The sulphuric acid has decomposed the red cyanide, and given rise to a substance which fixes itself slowly and uniformly upon the pieces. This matter is at first of a greenish-yellow colour, afterwards of a dark green; and this green substance fixed in the fabric, changes under the influence of the air, the salt of tin, and the heat of the bath, which rises to 140° Fahr., to a blue colour, known as Prussian blue.

For many years it was a matter of great difficulty to produce this dye uniformly. Uniformity is now easily effected; but the colour is partly abandoned, and replaced by the remarkable aniline dyes.

WORKSHOP FOR COLOURS EXTRACTED FROM COAL-OIL.

Colours.	Mordants.	Colouring Matters.
Reds (Magenta, Bengale, Rose)	Alcohol, Sulphuric acid, Salts of tin	Fuchsine, Aniline violet
Violets		Rosolane
Blues		Aniline blues
Greens		Aniline greens
		Violet (Hoffmann)
		do. (Paris)

The distillation of coal for the production of illuminating gas is conducted in clay retorts, and produces subsidiary liquid products known as coal-oil.

The principal products of the composition of coal, taking, for example, the coals of Angin and Mons, are, for one hundred kilogrammes of coal, as follows:—

Gas	22·94 cubic meters.
Coke	75·46 kilogrammes.
Tar	6·83 do.
Ammoniacal liquor . .	7·31 do.

The tar contains several substances, of which the principal are as follows, the respective composition, density, and boiling point being added:—

Substance.	Composition.	Density.	Boiling Point, Fahrenheit.
Benzine . .	C^{12} H^6	0·85	176° to 187°
Toluine . .	C^{14} H^8	0·87	221° to 230°
Xylene . .	C^{16} H^{10}	—	256°
Cumene . .	C^{18} H^{12}	—	304°
Cymene . .	C^{20} H^{14}	0·86	347°
Naphthaline .	C^{20} H^8	1·05	423°
Carbolic acid .	C^{12} H^5O HO.	1·065	370°

In order to separate these various substances, the raw oil is distilled in cast-iron retorts, and, as the temperature advances, the more volatile products are first distilled, and the distilling process is stopped when the temperature reaches 570° Fahr. The pitch, or residue, in the retort is utilized in various ways, but chiefly for the manufacture of artificial fuel.

The products of distillation are thus classified:—

1st. Those which pass over under 150° Centigrade, or 302° Fahr., comprising the lighter oils (benzine, toluine, xylene, cumene), and amounting to from three to eight per cent. of the weight of the tar.

2nd. Those which pass over between 150° and 200° Cent. or 302° and 392° Fahr. (carbolic acid and a small quantity of naphthaline).

3rd. The vapours last formed and condensed are called heavy oils, comprising carbolic acid, and especially naphthaline.

Benzine (C^{12} H^6), treated with nitric acid, is converted into nitrobenzine (C^{12} H^5 NO^4). Nitrobenzine, in presence of nascent hydrogen, produces aniline (C^{12} H^7 N).

Rosolane (Perkin's violet).—In 1856, Mr. Perkin, a pupil of Mr. Hoffmann's, discovered that by treating aniline with sulphuric acid and bichromate of potass a violet colour was produced.

Since that time, numerous researches have been made, chiefly

WORKSHOP FOR BL

BLACKS.

by Mr. Hoffmann, which have led to the discovery of numerous colours.

Aniline Red.—In 1859, it was found that aniline, treated with bichloride of tin or by arsenic acid, yielded the marvellous product called aniline red.

Aniline Violet.—In 1860 it was found that aniline red, heated with an equal quantity of aniline, to 356° Fahr., yielded aniline violet.

Aniline Blue.—This colour was obtained by heating to 374° Fahr. a mixture of aniline red with twice its weight of aniline.

Aniline Green.—Aniline red, dissolved in sulphuric acid, with an addition of aldehyde, formed into a bath containing hyposulphite of soda, yields a green colour (*vert lumière*).

Violets lumière.—Since 1862, in combining rosaniline with the bases of alcohol and wood spirit, a magnificent series of violets have been produced, known as *violets lumière.*

Contrary to the other colouring matters, as indigo, cochineal, madder, logwood, Brazil wood, fustic, &c., the colours extracted from coal-oil have a strong affinity for woollen tissues, but unfortunately they have no great stability. They are easily applied. Their affinity for wools is so strong, that they dye them in bright and intense colours without the aid of any mordant. There are, nevertheless, added to the dyeing baths certain chemical agents (sulphuric acid, bisulphate of soda, salt of tin) ; but it must be confessed that these act only partially as mordants, as they fail to render the colours permanent under the action of air and light.

The great success of these colours is owing to their beauty, their intensity, their brightness ; they immediately became the fashion. The number of pieces dyed yearly is considerable. At Clichy, they dye annually from 22,000 to 30,000 pieces of 80 meters (87 yards) each.

It is to be hoped that science and practice will ere long discover the means of rendering these colours permanent.

Like all other discoveries, this one has given rise to formidable processes at law, which have been, and will continue to be, the ruin of inventors. The monopoly given to one alone, has already had the effect of banishing from the country the manufacture of these magnificent colours, which has been prosecuted with great success in Switzerland.

It would be desirable that inventors should become rather the advisers of industry ; and a new law of patents is required, which should limit the discovery to the invention of new means or of new industrial products, and leave to each country the duty of recompensing its own inventors. "It is a matter of urgency," says M. Boutarel, in his "Report to the Exposition of 1867, Class 45," "to free our industries from the shackles which impede and retard their development: *we must cease* to sacrifice the general interest to a private interest. The inventor should no longer be isolated and penned up in his individual insignificance, by forbidding others to make up his deficiency. In one word, patents must be suppressed, they do not even accomplish the object of giving the inventor all the benefits of his invention. Moreover, invention is collective labour, often anonymous, to which humanity in general contributes, and which frequently springs up in several places at once ; so that it is often impossible to say with justice who is the first inventor. It follows from this revelation of various original ideas to several men, whether they be near together or separated by time or by space, that it is of the nature of invention that it does not belong, even for a limited period, to any one man ; and, in conferring an exclusive right of production, this privilege hinders cheapness of production.

"In fine, if the right to labour belongs to all men ; if this property is the first, the most sacred, the most incontestable of all, the temporary privilege accorded to inventors is assuredly a violation of the great principle of the freedom of labour.

"In discoveries, theory precedes practice, and thought precedes action. The inventor has the merit of the idea, but his discovery is often far from being practicable. It must be endued with life, whereas the inventor rarely perseveres in working out his invention to a practical issue. The persistence which knows how to draw from an idea all the useful consequences belongs to the working man.

"No industry suffers more from the action of the patent law than that of dyeing and printing. This arises, for the most part, from the fact that the patent laws are not the same in all industrial countries. There are even countries, as Switzerland, where there is no patent law in existence ; from which the consequences have been disastrous for French industry. For example, thanks to the labours of European chemists, organic chemistry has made such great progress that coal-oil has given birth to several volatile alkalies. One of these, aniline, by reason of its various industrial applications, has excited the liveliest sensation by the appearance of the violet, the red, the blue, the green, and the black of aniline. Like all important discoveries, this one has given birth to numerous patents. Forthwith, Switzerland and other countries, innocent of patent law, commenced the manufacture of the new products on a large scale. They alone have profited by their freedom of industry. They have perfected the processes, and have delivered to their customers productions superior to ours, and at half the price which we were forced to pay to the patent monopolists at home. The patent law of 1844, recognising only the interest of the inventor, and thereby neglecting glory and national riches, struck a blow at industry in general, the prosperity of which is sacrificed to that of an individual.

"To make the most of discoveries, they should be given up to the public ; and it is only when they are tried, and applied by those who have the aptitude for doing so, that they can attain to their full development. The rapid development of great discoveries can only be effected by the concurrence and free co-operation of various intelligences.

"The devolution of all discoveries to the public domain will enlarge the circle of industrial activity, will promote cheap production, will enable us to compete on equal terms with other countries, and will free our various industries from the impediments which place them in a position of inferiority."

Washing.—When the pieces leave the colour-tubs, they are, of course, saturated with an excess of colour which must be washed out of them. The washing process used to consist, and in some places, and for certain stuffs, continues to consist, in attaching the pieces to stakes fixed in a watercourse, the rapid current of which opened out the piece and removed the free colouring matter. At Clichy the washing is conducted methodically by specially contrived apparatus. The fine colours are washed in tubs specially appropriated for them, and fitted with turnstiles moved by mechanical means. The heavy colours and the blacks are passed through an apparatus called the *rivière anglaise.*

Rivière anglaise.—The pieces, when taken from the dyeing-tub, are bound end to end, and plunged into a concrete basin full of water, and are actively moved about in the water by a man with a stick. The pieces are afterwards engaged between two cylinders under a heavy washing rain. The rotation is slow but continuous, and the vertical action of the rain is very effective. Continually drawn by the motion of the cylinders, the ends fall into a second and smaller basin, into which water is discharged from a pipe of large section, where they receive a first rinsing. From this basin the webs, which are continuously exposed to a vertical rain, are removed between other cylinders, from which they are delivered thoroughly washed, when they fall into and are collected in large open-worked baskets. They are then folded and carried to the centrifugal machines for expelling water.

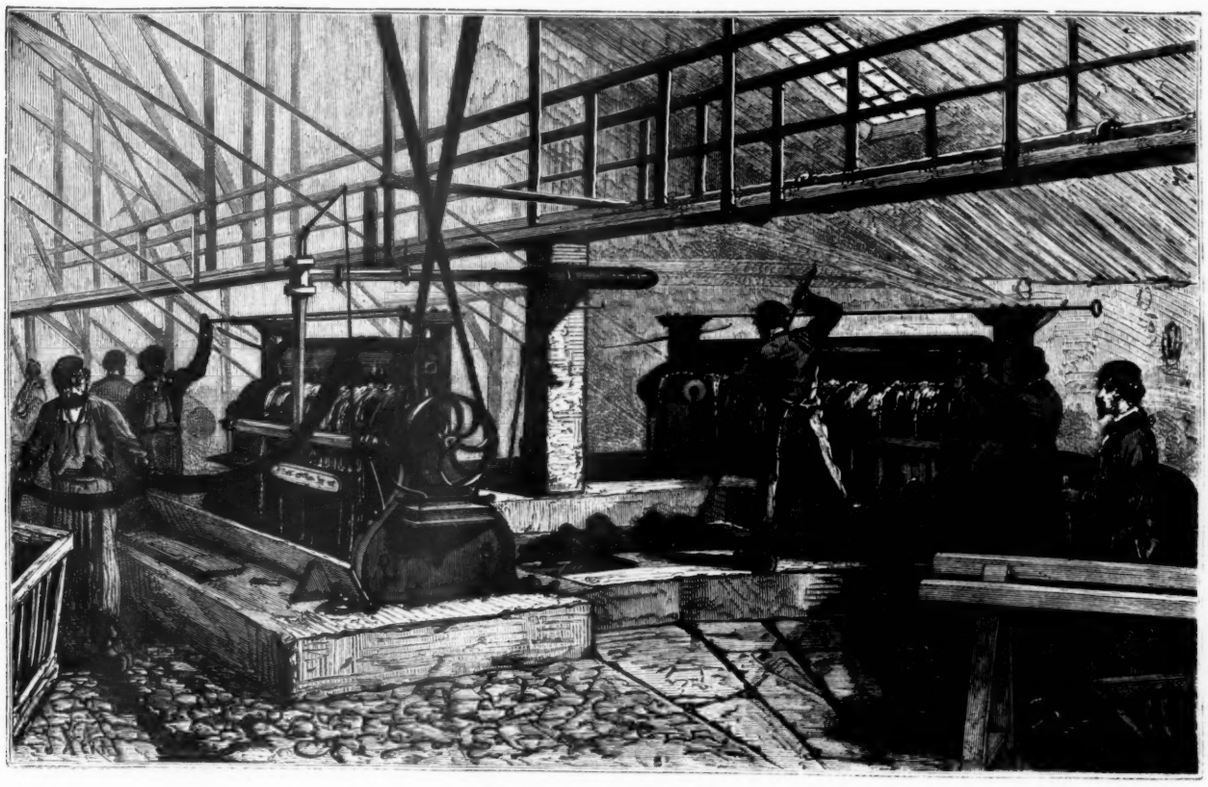
The *rivière anglaise*, with the other apparatus of the factory, consumes daily a considerable quantity of water. The water is pumped from the Seine by means of seven pumps into reservoirs standing at an elevation of about 26 feet. These pumps supply about 70,000 cubic feet of water for ten hours' work, and with the water which runs from the factory a good sized water-wheel might be turned ; but as there is not a sufficient fall, the water is returned direct to the Seine.

The centrifugal machines at Clichy are not on the usual centrifugal principle—a cylindrical vessel revolving on a vertical axle—but they consist of large square baskets turning on a horizontal axis, bound by strong bars of iron, and may be revolved without danger at a rapid rate, notwithstanding the great weight of the wet materials which they carry. The greater proportion of the water having been expelled by this machine, the pieces are taken to the drying-room, cold or heated, as it may be, and finally dried. There is one room for the light colours, another for the dark colours. These drying-rooms are immense chambers roofed over, and very elevated ; they are divided in height into two parts by wooden bars to carry the webs. In order that the drying and the fixing may advance uniformly, and that the piece may retain a uniform dye all through, it is necessary to have an equal volume of air above the bars as below.

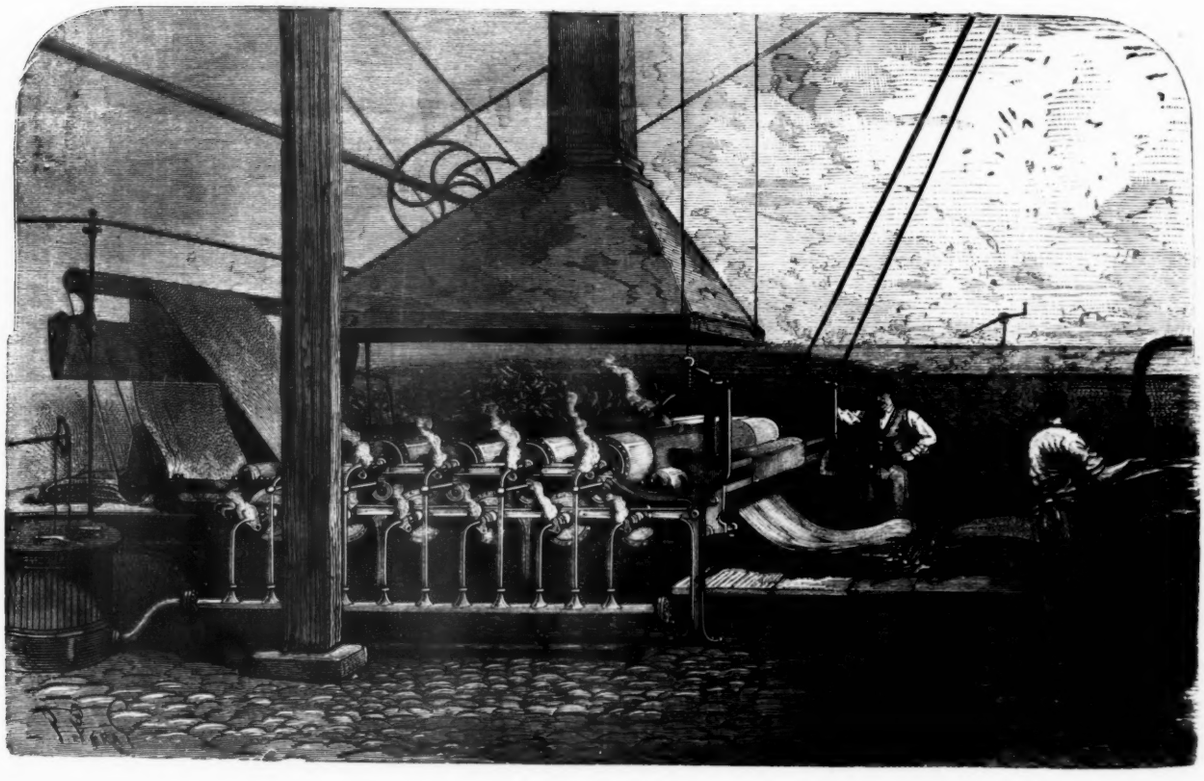
Steam-Drying Apparatus.—The pieces destined to be dried in hot air are taken to a steam drying apparatus, constructed by M. Tulpin, of Rouen, and consisting of two rows of hollow cylinders, heated by steam, and geared together, so that the revolution is effected without throwing any strain on the web, and thus the lightest fabrics may be dried without affecting the parallelism of their fibres.

Inspection.—On leaving the drying-rooms every web is submitted to repeated examination by special and practised examiners, who first compare the pieces with the same sample, to ascertain whether they are precisely of the same shade. If the shade is not satisfactory the piece is sent back to be dyed again, or, if the fault be irremediable, it is dyed black. The same examiners ascertain what pieces require to be picked or weeded.

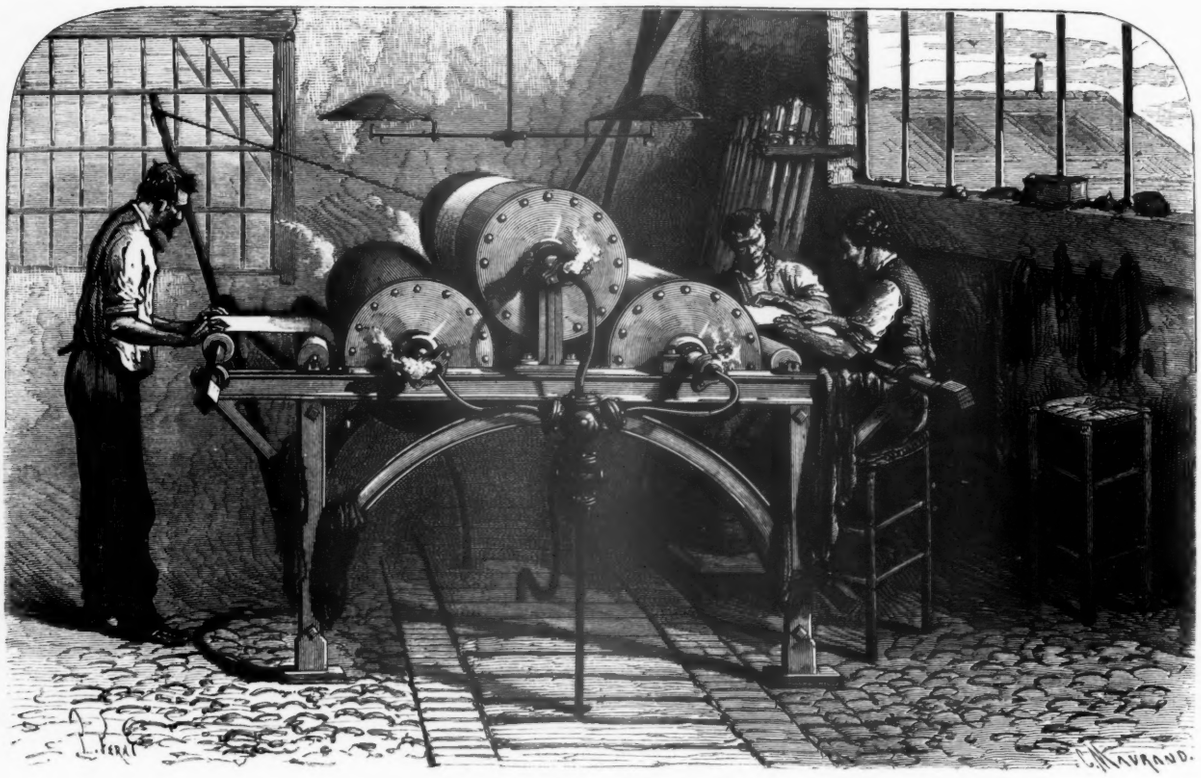
Picking.—Women, called pickers (*épailleuses*), are employed



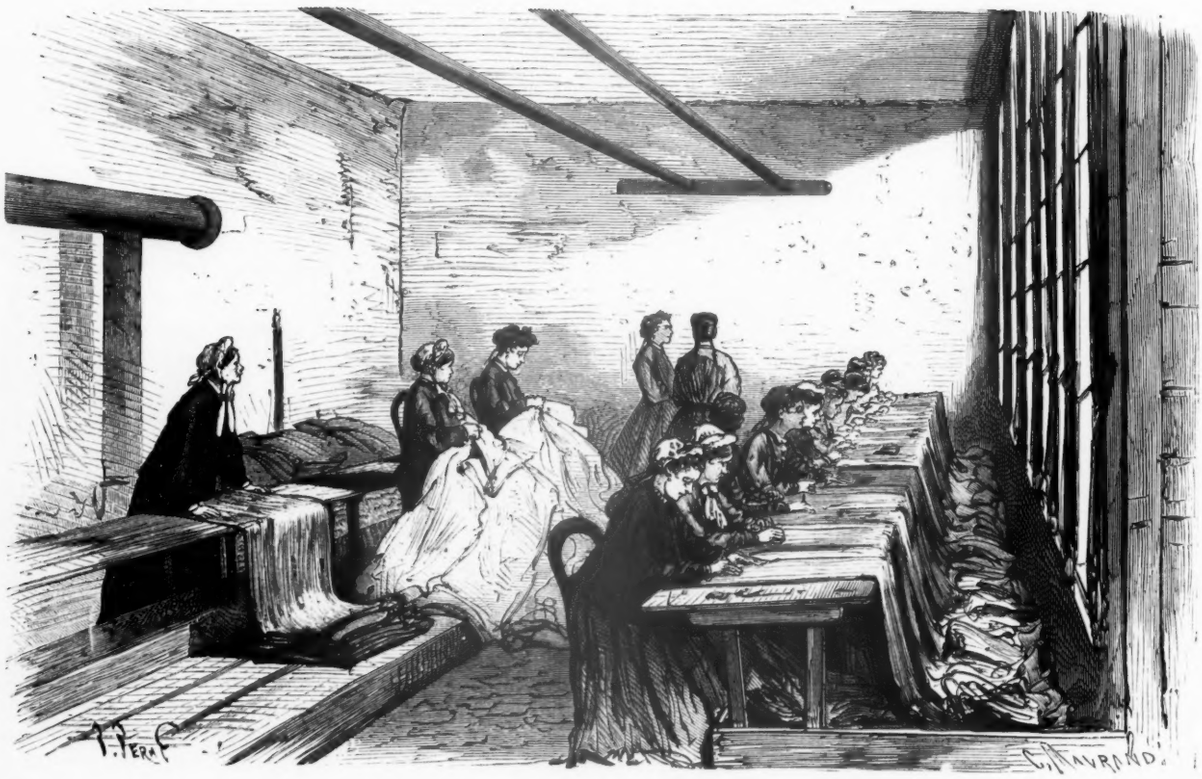
"RIVIÈRE ANGLAISE."



STEAM DRYER.



INSPECTING FRAME.



PICKING ROOM.

PICKERS.

to weed from the fabric, with small pincers, all the little stray threads, fibres, or straw not previously combed out, or which may have been twisted in with the warp or woof.

DRESSING.

Formerly, the operation of dressing was a simple matter; now-a-days, for certain stuffs, the dressing contributes three-fourths to the appearance of the stuff. Certain foulards, for example, and certain calicoes prepared for exportation, are little more than canvas washed with gum, starch, and other matters not usually considered to be fibrous.

With wools it is different—the dressing is purely mechanical, not chemical; the picking itself, which, it was hoped, might be superseded by the use of agents that would attack the vegetable matter without injuring the animal matter, is always done by hand.

Shearing.—The first operation is shearing. The workshop for shearing is the finest of its kind that we have seen. There are twenty machines, each of which is capable of taking in two webs at once, placed in two rows and worked by a small number of attendants. They are all provided with folding apparatus, in which the web is engaged when it leaves the cylinders of the machine.

By the shearing operation the piece acquires a uniform surface; it is next folded by hand in two, in the direction of the width, for the sake of compactness, before being passed through the smoothing machine.

Smoothing Machine.—This machine consists of three hollow cylinders, of about sixteen inches in diameter, into the interior of which either steam or cold air may be admitted at the will of the operator, so as to heat or cool the cylinder, as may be required. The pieces, previously to entering the machine, are slightly damped by a fine rain, which falls through a silk sheet in a finely divided state.

The merino or the cashmere extends in front of the machine, laps round the cylinder, and, as it leaves the last cylinder, it is seized by two workmen, seated one at each side of the machine, whose duty it is to stretch the stuff and draw it regularly, so as to maintain it of uniform width, and thus to counteract the contrary action of the machine, which draws the web longitudinally. One of the men inserts one of his fingers between the two selvedges, constantly re-adjusts the edges to each other, before the piece passes on to the roller. At the same time, the other workman watches the fold in the middle of the web on the other side to keep it regular. This operation, simple as it seems, demands great strength in the fingers, and great experience to do it well.

After having been smoothed and straightened, the pieces are removed on the rollers into vaults, which are maintained in a cool and slightly humid condition, where they remain for forty-eight hours.

Hydraulic Presses.—Certain stuffs which require to have a glazed finish are submitted to strong pressure in the hydraulic press, with a sheet of pasteboard interleaved in each fold, elastic like leather, and as smooth as burnished metal. Heat is applied to the pile of webs to facilitate the glazing, by means of highly heated cast-iron plates, which are cased in thick felt.

Despatch of Goods.—The webs are finally folded on the measure, and again examined one by one, after which they are delivered into the warehouse for despatch. A last operation consists in rolling each web on a small board; then the pieces are packed and despatched to all quarters of the globe.

The warehouse is not the least curious part of the works. There may be seen the nature of the stuffs and varieties of shades in fashion; and one may also observe in what directions they are destined to be despatched. These woollens appear to be highly appreciated in the extreme East.

The works at Clichy are a striking example of an industry in which all the advantages supplied by modern science have been intelligently applied, under the care of a good general direction. MM. Boutarel and Chappat make no secret of their manufacture. They open their doors wide to strangers. Every year the pupils of the Polytechnic School, the Central School, the School of Commerce, &c., are cordially received by the proprietors, and the managers are always ready to make known the practical applications of the discoveries of our scientific men.

THE COAL-FIELDS OF GREAT BRITAIN.[1]

THE appearance of a third edition of Professor Hull's work on the coal-fields of England, Scotland, and Ireland, embodying, as it does, the reports of the Royal Coal Commission, is very opportune. Although the events of the past year, leading to an unexampled rise in the prices of mineral fuel, have passed into history, the after effects cannot fail to be felt for a long period, nor can we anticipate, at least for some very protracted interval, that the advance in prices can be very materially reduced. In a former article in these pages, Professor

[1] *The Coal-Fields of Great Britain: their History, Structure, and Resources.* By Edward Hull, M.A., F.R.S. Third edition, revised and enlarged. Stanford, 1873.

Leone Levi[1] very ably discussed the whole question; but its extreme importance leads us to a reconsideration of the subject, and we shall therefore endeavour succinctly to present further details respecting the prospects of coal-winning in these islands, and their probable effects upon our commercial status throughout the world. Taking, therefore, the exhaustive work of Professor Hull in its new and extended form as our guide, let us see what facts of interest have transpired since our last review of the matter.

Historically speaking, the immense industry of coal, so familiar to all of us at the present day, is of no considerable antiquity; and when we inquire into its first history, we do not find that there was anything like a progressive foreshadowing of the immense activity now displayed in the business. Professor Hull tersely observes that, "like many other treasures of nature, the use of coal did not become general until its necessity had become paramount. While in the days of Anglo-Saxon and Anglo-Norman art, and those which immediately succeeded, the plains of England were overspread with almost continuous forests, growing as in Staffordshire and Lancashire, frequently in dense luxuriance over the mineralized forests of geologic ages; and while those forests readily yielded an abundance of fuel for all the purposes of the times, it was both unnecessary and improbable that the labour and risk of mining should become general. The precious mineral was reserved for a generation to whose very existence it is almost a necessity; a generation that without its aid could scarcely (as far as we can see) have arrived at the position in art, industry, and navigation which it has attained in the nineteenth century."

Although in modern times such astonishing new facts are constantly coming to light respecting antiquity, that we may at any time have to reverse our present ideas on almost any subject, yet it does not seem that the ancients made any very great use of coal. The coal so frequently mentioned in Scripture is evidently charcoal; the mineral deposits of coal as yet known to exist in the districts of the Holy Land and Arabia being very few indeed. During the Crimean War coal was, however, fetched from Heraclea, on the Black Sea, but of a very inferior quality. Theophrastus (B.C. 238) is the first author who mentions coal as at present understood, and according to him it was used by smiths in their forges. It seems, however, to have been mere surface coal. Pliny and Strabo also name a certain earth called *Chia terra*.

Descending to later times, we find that the Britons of very great antiquity, when still in the flint implement stage of civilization, made some use of coal, and even seem to have known some primitive kind of mining, and a rude ornament carved in cannel, or candle coal, was found in the parish of Dundonald, fifty feet above the sea level. It was estimated by Sir Charles Lyell that this ornament dated from B.C. 1500. Solid oak pick axes were also found in old workings near Stanley, in Derbyshire, when a heading was driven through the Kilburn coal. Stone hammer-heads and wedges of flint were also found near Ashby-de-la-Zouch, with wheels of solid wood. Other indications of a very early use of coal have been found, but the evidence is open to grave doubt.

When we arrive at the time of the Roman occupation of Britain we obtain conclusive evidence that the practical colonists of Rome made use of coal for domestic purposes. Mining of a special kind has been found to have gone on not far to the north of Wigan in Lancashire. A coal seam of six feet on the Arley mine was found to have been excavated in a very peculiar manner, consisting of a series of polygonal chambers, with vertical walls, opening into each other by short passages, the ground plan presenting the appearance of a honeycomb. "There is something," says Professor Hull, "in the symmetrical arrangement and regularity of the works peculiarly Roman, reminding one of their tesselated pavements or the ground-plans of their baths and villas, in which symmetry of form appears to be the guiding spirit." Mancunium, the modern Manchester, was a Roman station, and about a century ago cinders and scoriæ were turned up among other Roman remains. A quantity of Roman coins were also found in beds of coal cinders near North Brierley, in the West Riding of Yorkshire. Other similar indications have been discovered in various parts of Roman England.

When, however, the Anglo-Saxon period has commenced, we begin to find coal absolutely mentioned in the histories of the land. The Saxon Chronicle of the Abbey of Peterborough contains the following notice:—"About this time (A.D. 852) the Abbot Ceolred let to hand the land of Sempringham to Wulfred, who was to send each year to the monastery sixty loads of wood, *twelve loads of coal*, six loads of peats, two tuns full of fine ale, two neats' carcases, six hundred loaves, and ten kilderkins of Welsh ale, one horse also each year, and thirty shillings, and one night's entertainment." Doomsday Book, in other respects so valuable, contains no account or valuation of the mineral wealth of the country, and hence there is no mention of coal in that record. The Boldon Book, published in the reign of Henry II., however, refers to coal on two occasions in connection with Vernouth (Wearmouth) and Seggefeeld. In 1180 a grant of land was made to a collier for providing coals to a cartsmith at Counden, in the county of Durham.

"The year 1259 is memorable in the annals of coal-mining. Hitherto the mineral had not been recognized by authority or in any public document; but in that year King Henry III. granted a charter to the freemen of Newcastle-on-Tyne for liberty to dig coals. Under the term 'sea coal' a considerable export trade was established with London, and it speedily became an article of consumption amongst the various manufacturers of the metropolis. But its popularity was shortlived. An impression became general that the smoke arising therefrom contaminated the atmosphere, and was injurious to the public health. Years of experience have proved the fallacy of the imputation; but in 1386 the outcry became so general that the Lords and Commons in Parliament assembled presented a petition to King Edward I., who issued a proclamation forbidding the use of the offending fuel, and authorizing the destruction of the furnaces and kilns of all who should persist in using it. This was a year before the monarch's death, and the year which saw the overthrow of his life-long attempts upon the throne of Scotland, through the intrepidity of Robert the Bruce. But the proclamation against coal was as abortive as the endeavour to conquer the patriotism of the Scots. Prejudice gradually gave way as the value of the fossil-fuel became better known, and from that time downwards its use became more extended; and it is very probable that throughout the fourteenth and fifteenth centuries coal was extracted near the outcrop of the beds over most, if not all, of the coal-fields of Britain and Ireland." (Pp. 28-9.)

From this time forward the use of coal as fuel gradually extended throughout the whole country, and thus grew up the mighty industry which has raised England to the pre-eminent position of Queen of Nations. During the fourteenth century marked extension took place in coal-mining, first about Newcastle, and soon after in the county of Durham (1343). At this time the principal pits worked were in the districts of Newcastle, Elswick, Bertley, Winlaton, Merrington, and Lanchester. The earliest instance of the shipping of coal from Sunderland occurs in the rolls of Whitby Abbey, in 1395, when thirteen shillings and fourpence were paid to William Rede, of Sunderland, for four chaldrons of coals.[1]

A curious picture of the social life of Scotland in the fourteenth century is afforded by Æneas Sylvius (afterwards Pope Pius II.), who records that he saw the poor receiving pieces of coal as alms at the gates of the monasteries to burn in lieu of wood, "of which," he adds, "their country is destitute." It is evident that the monks at this time, with their characteristic business habits, did not neglect to take advantage of the new fuel, as we find them leasing collieries at various places, such as Tynemouth Priory letting the Elswick Colliery, in 1330, at a yearly rental of six marks.

The coal trade, as a distinct branch of commerce, seems to have consolidated itself in London during Richard II.'s reign, about 1381, according to Rymer's "Fœdera;" yet it took 225 years to render it a staple fuel throughout the kingdom. After the reign of Queen Elizabeth, under Charles I., and later on, the House of Commons were forced to make regulations for the coal trade, the enormous price of four pounds sterling per chaldron having been reached, after the capture of Newcastle by the Scottish army.

Very poor must have been the condition of the working collier in those days, ere the Steam-engine and Davy-lamp had been heard of. It is a sad picture to think of the colliers working either in total darkness, or illuminated only by the phosphorescence of dried fish. Afterwards, however, we find steel mills with multiplying wheels used, which by contact with flint stones produced a succession of sparks, dimly lighting up the workings. At a later period, torches and candles came into use in mines where carburetted hydrogen existed in very small quantities.[2] The middle of the sixteenth century witnessed the introduction of the horse-gin, still used in some mining districts. Pennant, in his "Tour in Wales," says there is evidence to show that the coal seams of Mostyn, in Flintshire, were worked as early as the reign of Edward I.

[1] "Our Coal Supply," p. 67.

[1] "Proceedings of the Archæological Institute of Newcastle," vol. i.
[2] Hull, Appendix E, p. 484.

The Warwickshire coal-fields were first worked in or about the year 1600, and the celebrated cannel coal of Lancashire and the Durham collieries began to be worked at about the same period. Dr. Plot, in 1686, describes the winning of coal and clay ironstone at Tunstall and Silverdale in North Staffordshire. The Irish coal-fields appear also to have been worked at a very early date, as traces of abandoned workings a century and a-half old were found in 1770 at Ballycastle. Scotland also at an early date began to use its mineral treasures; and it is melancholy to think that the miners of Scotland were held in a state of actual and legal slavery down to the year 1799, when an Act was passed declaring them free from personal servitude.

The coal duties, in a grimly humorous manner, arose out of the great fire of London, and the Lord Mayor was granted an impost of one shilling per chaldron for rebuilding the city—subsequently increased to three shillings. Probably this duty was found so easy in days of monopolies, that it need not surprise us to find an additional tax of two shillings imposed by Parliament in 1670 for the re-edification of fifty-two parish churches; and the friendly fuel furnished another three shillings per chaldron, this time for rebuilding St. Paul's Cathedral. At one great crisis of English history, during the protracted war with France, the coal-tax rose to nine shillings and fourpence per chaldron. This, however, by a wiser and more economical system of fiscal science, has been now repealed, the City and Orphans' Duties alone remaining, amounting to thirteenpence a-ton.

From the time that municipal control over the coal trade became an accomplished fact, we observe an altered character in the whole of its operations. That desire, so rife in the aldermanic breast, of achieving a brief reputation by fussiness, at the expense of accuracy, became rampant, while the City of London in its corporate qualification held on to its new functions with an almost ludicrous tenacity. The whole arena was cleared for men of far less individual insight in the early reigns of the Georges; and, with honourable exceptions, the London coal trade was ruled by persons eminently disqualified to attend to the real interests of an important staple. From monarch to beggar there was a dreamy unfaithfulness to practical affairs. It will so happen, even in trade matters, in the life of all nations; and therefore why not the English nation among the rest? The life of the sixteenth century, and all its activities, was not only stimulated by civil war, and subsequently raised in the seventeenth to a pitch of unexampled self-glorification by the revolution of 1688, but it held within itself the seeds of indolent self-gratulation and easy acquiescence in the peculiar political system of Walpole, succeeding to the variously masked *insouciance* of Bolingbroke, Hobbes, and Shaftesbury. Minor details of commercial life, fettered by a thousand ties of self-interest, met with no attention; and while imports were encouraged, they received no grave attention at the hands of the few political economists then in existence. What, therefore, is the result? Under the mask of perfect freedom, coal, to this hour, has actually, though not nominally, continued a monopoly.

But the business of winning and distributing coal cannot remain a monopoly, even in an extended sense, much longer. It will ever exist as one of the most efficient supports of the prosperity of this country; for at the time when we broke off what may be termed the *précis* of Professor Hull's history of coal mining, there was preparing to appear the Mercury of a most singular and still incomplete era. James Watt, whose name for real practical good in this world is of an immortal nature, was gradually rising up, and his fame was destined to eclipse that of the nugatory aldermanic corporative body imposing a monopoly on that of which they had only a temporary custody. In point of fact, Watt invented the steam-engine dreamt of by Hero of Alexandria; but without the coal measures of our country the steam-engine would have remained, like many other of our philosophical instruments, a stunted toy, worthy only of an occasional glance of amusement, and, in the eyes of some persons, of despair. With James Watt there arose a new reason for increased activity in taking out the coal measures, and the year 1784 should ever be marked, by geologists and manufacturers alike, as a boundary stone between manual labour on the one part, and the effectual triumph of a philosophical and benevolent theory on the other. Science, in its dual form of practice and theory, received its apotheosis when a worthy application was found for the natural treasures contained within the earth's crust.

In thirty-one years from that time Sir Humphry Davy effected the second great necessity of coal mining—the safety-lamp; and since then, in an ever-increasing ratio, the prosperity and comfort of mankind have received singular and certain advancement. But as every prosperity contains within itself the seeds of disintegration, so we shall subsequently see that without prompt measures in our own time we may look for unexampled difficulties. As Professor Hull says, "With these inventions a thousand new uses for the application of coal sprung into existence: railways, factories, steamboats, iron furnaces, were multiplied; and Britain, owing to her enormous riches in coal and iron, taken advantage of by a people endowed with indomitable energy and intelligence, was enabled to place herself in the front place amongst the nations of the Old World."

Perhaps one of the most astounding fallacies accepted by a contentedly acquiescent public, firm in its reliance upon its established coal-merchant, is the fallacy touching Wallsend coals. In the list, so ominous to many a householder, and so curiously and anxiously scrutinized by the house-father on his way to business, and the house-matron on her afternoon round, we observe conspicuously at the top the price of Wallsend coals—so and so many,—alas!—shillings. To adopt the Attorney-General's classic phrase, "Would you be surprised to learn" that there is not, and has absolutely not existed for many a long year, such an article of commerce as Wallsend coals? Not a "nubble" has been raised from the Wallsend district for many a year. The old pit industry in the straggling village of Wallsend, deriving its name from its topographical situation at the termination of the famous engineering trophy of Romano-British science in the era of the Emperor Hadrianus, is now at an end—happily not for ever;—for it is hardly to be anticipated that with our present demand for coal and scientific appliances the drowned pits will not be pumped out. The chief of these abandoned workings are Russell's Wallsend Main, the Old Wallsend pit, and the New Wallsend Colliery; and strange sights may be seen in wandering amidst this deserted field of labour. The miners have now migrated to new quarters, and where there was formerly the busy hum of men there is now silence and desolation. The palmy days of the Wallsend industry preceded those of steam, and the name still preserved was then associated with household coal only. From Blaydon, on the western side of Newcastle, to Cullercoats, on the eastern coast of Northumberland, there extends a section of the famed Ninety Fathom Dyke. In a triangular area, shut off by this dyke, lies the early home of the Wallsend household coal, its only output.

Coal, it is recorded, was first won on this area about the year 1781; but there were workings of a long anterior date—probably those of the corporate body of Newcastle colliers in the days of the Edwards. Tall trees were growing in 1815 above these long-forgotten shafts. The property belonged to the families of the Lords Ravensworth, Strathmore, and Wharncliffe, the Russells of Brancepeth, Matthew Bell, the Brandlings, and many more. Common interests induced a species of alliance on the part of these personages, and they formed a kind of semi-political faction amongst themselves—carrying on the trade not without a certain kind of rude magnificence—with periodical festivals, balls, and other species of "high jinks" not unagreeable to the Northumbrian mind. One great entertainment took place at Gosforth in 1829, the ball-room being some eleven hundred feet underground, spacious, lofty, and brilliant. Three hundred guests assembled at an early hour in the morning, somewhere about half-past nine, and dancing was continued till three in the afternoon. The side of the ball-room was formed of the coal-seam itself.

But in striking contrast with such gorgeous festivities in the bowels of the earth is the daily life and danger of the colliers themselves. It is not surprising to find the miners reckless, and almost foolhardy—nay, even dangerous—from similar causes. In the old pits of Wallsend, before modern science had aided in somewhat lessening the risks the men had to encounter, it was literally the fact that the men worked, as it were, with their lives in their hands in those gloomy recesses of the earth. The two foes to be dreaded and defied were fire and water; explosive gases were readily generated in the seams of the Wallsend coal, and water abounded, so that an explosion might at any moment lead to an inundation.

The following list will give some idea of the number of lives lost at Wallsend. In 1803, thirteen miners were killed; in 1806, ten; in 1809, twelve; in the Killingworth Colliery, in 1814, twenty-four miners were lost; at Percy Main, in 1818, four; but in 1821 the number was vastly greater, fifty-two sufferers losing their lives; in 1835-6, one hundred and twelve persons were killed. In the Heaton Colliery, in May, 1815, there was a terrible inundation. The water burst in like a torrent, and reached the height of nineteen fathoms in a few minutes, increasing to thirty-three in a very short time, the pumps proving utterly ineffectual. Forty-one men and thirty-four boys were in the pit at the time; not one of these could be rescued, and even the bodies could not be found until the next year, when, in January and February, the sad procession wended its way to the trenches dug in the churchyard of Wallsend. Coroners' inquests were pitiable farces in those days, the stereotyped direction to the jury being "that this was one of those lamentable accidents which were so common to coalpits, and which no human foresight could prevent."

It is somewhat of a singular fact, related to the writer by a gentleman who at one time greatly interested himself in the condition of the Newcastle miners, that despite their desperate life they evince, as a body, the keenest interest in matters of science, politics and religion. No wandering lecturer who strays into their company is unwelcome, and they eagerly listen to anything new or strange concerning that outer world of which they are scarcely denizens. The form which religious enthusiasm assumes amongst the mining population is that of Wesleyanism or Primitive Methodism. In physique and mental characteristics they are hard-featured, full-eyed and stalwart; energetic, specially fond of rude independence, and there is no want of a kind of geniality of feeling under their rough exterior. Many of the men are ingenious, fond of experiments in the natural sciences and mechanics, devoting much of their leisure to the construction of models of engines and other objects of practical utility.

The frightful series of catastrophes enumerated above were a sign that the water enemy was growing more and more formidable and less easy to combat. In the early days of coal mining the whole method of taking out the precious carbohydrate was wasteful in the extreme, and thus it is no wonder that the Wallsend collieries, in the face of such risks, were carelessly worked. The pits became gradually abandoned between 1835 and 1845, and, except the Walker Colliery, there is not one now absolutely worked. It is much to be regretted that steps are not taken for the recovery of the fine upper seams still known to exist; the task has to some degree been attempted on a somewhat considerable scale. The Tyne Coal Company has been at work since 1867 with powerful pumps, at any rate proving that the ultimate rescue of these mines is possible. Hebburn Colliery, on the south side of the Tyne, but connected subterraneously with the northern system, is now at work, and attempts are still being made to conquer the other side. The difficulties are best to be appreciated by a general description of the process by which coal is actually won.

In forming the mine deep shafts or pits of some ten or fifteen feet diameter, either round or square, are sunk, and continued to enormous distances through all the seams of coal, with their intermediate strata of shale and other formations. The shafts are usually lined with brickwork and with timberwork called *tubbing;* but iron linings are now generally adopted throughout the mining districts. These pits are necessarily very deep, as in the northern counties, in the districts to which we have just referred, coal is seldom reached at a closer proximity to the surface than one hundred and fifty feet. This is by no means a limit, however, as two thousand feet and even greater depths have still shown seams worth working; and there can be little, if any, doubt that very much greater depths will be attained in the future all over the country. At each seam, as it is passed through, a lateral passage called a *bord*, or *mothergate*, is excavated in the seam itself, the ceiling of which is called the *roof* and the floor the *sill*. From this *bord* other galleries are thrown out at right angles to get at the coal; these are called *headways*. To secure drainage a *main level* is cut out, winding in and out so as to collect the water in all directions as much as possible. The number of *bords* made in each seam depends upon circumstances, as also the still greater number of headways connecting them together. The seam is thus cut up into a kind of town of broad streets and narrow lanes at right angles to each other.

The masses of coal between these passages are called *panels*, and in working out the coal these panels are dug out one at a time. As the passages thus become widened, the gaps are strengthened by timber *girds* or props supporting the roof; at a subsequent time, if it can be done with safety in any part of the seam thus exhausted, these girds are taken away, and the roof is allowed to fall down into a heap technically known as a *goaf*. It is in these *goafs*, however, that the miner's greatest enemy, *firedamp*, accumulates, and hence the fearful accidents unhappily so frequent in the collieries. This method of working the coal, however, is not the only one employed, as in some very thick seams, of some thirty feet, such as occur in the mines of Staffordshire, it was found inapplicable. In such circumstances the miners dig a horizontal channel at the bottom of the coal, called a *hole*, and insert small stone props or *cogs*, making other vertical channels in order to get at the coal for the purpose of separating it into blocks for removal. Some of the blocks at the base are left untouched to form a further support for the superincumbent mass, but others are cut into at the sides and bottoms, the natural cleavage being taken into account. The men having been withdrawn to a convenient distance, or place of safety, the whole block is brought down with a crash preparatory to removal, and thus sufficient room is obtained for the successful excavation of the remainder. These huge masses are now also worked upon with coal-cutting machines in a much more expeditious manner.

The terminology of the various workers in the South Staffordshire coal-mining districts, where the ground is honeycombed, is as follows:—The *holers* or *pikemen* cut round the sides and bottom to separate the coal into blocks. The *bandsmen* are stationed at the ropes by which the various kinds of hauling and lifting are effected. The *turners-out* are employed in breaking the large blocks of coal as they fall into reasonable dimensions for transport and hauling up. The coal then passes to the *loaders* or *skippers*, who fill the skips, which are bound with iron hooping by the *putters*. The coal is next conveyed on sledges or trucks, by the tramways of the bords and galleries, to the bottom of the shaft. Here there is another workman stationed, called the *hanger-on*, who attaches the skip to the rope or chain which draws it up to the surface. The *dirt-carriers* clear away the ground about the holes. The *cleanser* separates the rough stony matter inseparable from the fossil fuel, throwing it into a heap called the *gob*.

Very pitiable is the condition of the miner in the lowest stratum of the coal, the cavity in which he has to work being at times little more than two feet high; and there crouched down, the coal has to be removed, as best it may, by the labourer. Wherever it is possible, ponies or donkeys are employed in drawing the trucks of coal, but where these cannot pass, boys push the trucks along the tramways. Till legislative enactment interfered, women and girls were thus set to work in areas often not more than two and a-half feet high.

We have now to return to the surface. Coals are brought up in vessels and lifts of various shapes, in many cases by the aid of steam or water-power.

The coal-mines, in a majority of instances, are so deep that it becomes very laborious for the miners to descend to the scene of their activity at the commencement of their day's labour—still more difficult is it for wearied men to return therefrom, the day's work completed. As we have already said, many mines are quite two thousand feet deep. In former times the means of reaching these depths was by ladders, each fifty feet long, placed nearly upright in the shafts, but at a later period these ladders were shortened and fixed in a more sloping position, so that they should form a kind of zigzag from the top to the bottom, each shorter ladder resting on a *sollar* or platform. But the distance thus to be traversed was so great, that it frequently took an hour for a man to reach the surface from the time he began his ascent.

In Cornwall, a man-engine has been adopted to obviate this terrible labour. By this arrangement two timber rods, placed side by side, extend vertically from top to bottom; these have a reciprocating up-and-down motion, with a range or distance of six feet, each having also a number of stages six feet apart. By stepping across from a stage on one rod to a stage on another, backwards and forwards, the miner, while on his descent, contrives always to be on one particular stage during the descending movement of that particular rod, and the contrary when on his ascent. Thus the difficulties of ascent and descent are much alleviated, these rods being kept in up-and-down movement by steam or water power. This system, although an improvement on the ladder system, has in very recent years been obviated by safety-cages and platforms worked by steam-power.

The safety-cage, as it rises to the folding trap-door at the top of the mine, opens the door, allows it to close again, and rests upon it; the coals contained in the hutch brought up by the cage are removed, hutch and contents, and wheeled along a tramway to a platform; an empty hutch is substituted in the place of the one removed, and descends the pit again. At the platform the coals are precipitated through an opening on to a screen, by which they are screened into large or small. This last operation performed, the coals pass to the railway companies or barges for loading or transhipment.

The *firedamp*, which, accumulating in *blowers* emitting seven hundred hogsheads of carburetted hydrogen gas per minute, often lasting for several months, may be called the Mine Fiend; but here the beneficent invention of the Davy-lamp has quelled it, so far as human caution can do. The frequency of the appalling accidents which had occurred by the too reckless tendency engendered in the mining population regarding their own safety, either in opening these safety-lamps or in otherwise exposing themselves to risks—often in foolhardy emulation—led to legislative enactment on the subject in the year 1850. Yet although the number of deaths in 1848-9 averaged 985 per annum, the mortality as estimated by Mr. Dickinson, one of Her Majesty's inspectors for Lancashire, who has made a comparison of the mortality between the colliers of Belgium and this country, showing the proportions of deaths from all causes, as estimated by the number of hands employed in Great Britain to those of Belgium, were, in the year 1852, as 5·32 per thousand to 4·05; yet when estimated by the standard of the quantity of coal raised, the comparison is in favour of this country (as Pro-

fessor Hull says), in 1851 and 1852, in the proportion of one life for every 54,822 tons raised in Britain, and in the proportion of one life for every 31,000 tons in Belgium. This speaks volumes in favour of the philanthropic employment of machinery amongst ourselves, as compared with the methods adopted on the Continent.

It is somewhat more in the domain of geology than in the sphere of the present magazine to say much about the composition of coal. When the coal formations took place man had not appeared on the earth. It was impossible for him to have existed in such a heated atmosphere, amidst such a luxuriant body of decaying substances. Vegetable matter of whatever kind is chemically fatal to animal life, whereas in man there exists a continual porosity. This porosity, commencing from the outer integument, extends to the viscera and to the skeleton, which even in our time is formed most delicately in low latitudes. Under such a heat as prevailed during the formation of the coal measures, if existing in any form, it would have been chemically absorbed, and would have left no trace behind. No wonder, then, that the coal measures proper contain no evidence of any kind of existence approaching that of our own species. The periods in which the submergence of the fossil forests took place is incalculable by any human practical ingenuity. A flora remains in its highly carbonescent condition, the only evidence, save that which geology has formed, of organic life on the globe. Without venturing too far on the ocean of speculation, we think it is not too much to say that the coal measures owe their origin partially, although perhaps not entirely, to a volcanic cataclysm. Historically, under our own eyes similar events are transacting themselves; and while we may yield much to the gradual action assumed by the ultra-geologists, we cannot avoid seeing, by parity of circumstances, that what occurred thousands or millions of years ago in our own islands is occurring nearer the equator, perhaps under different, but still similar, circumstances.

We should prove ourselves, however, very ungrateful to the early geologists if we did not at once accept the results of their inquiries into the origin of coal. Hutton, in his "Theory of the Earth," in 1785, by careful microscopic and chemical investigation, was enabled to show that the main source of coal fossil, such as in his time and our own exists, was chiefly of a vegetable nature. No doubt that life, in a detached animal (quadrupedal or octopedal) form, might have existed in that remote period, but the general train of evidence is in favour of a living flying population—in some cases amphibious, in all cases water-wanting. The general map given of the coal measures of England at p. 69 of this volume suggests that the group forming the British Islands was very little else than a scattered archipelago, successively sunk and raised by cosmical action. That anthracite coal can be found by our chemists subjected to the action of water and heat Professor Levi has already told us; why then, if the conditions of climate as proved by all cosmical history be true, need we doubt as to the formation on a large scale of our coal-beds?

"We are now," says Professor Hull, "in a position to comprehend in some measure the formation of a coal seam in olden time.

"Let us suppose that a certain bed of coal has been completed by the growth of luxuriant plants over a low-lying tract subject to inundations from the sea. Rising ground of granitic, schistose, or other rocks in the distance, defines the margin of the basin, and the boundaries of a continent from which the sedimentary materials of the coal strata are derived. That growth of vegetation marks a period of rest; but now a slow subsidence of the whole tract commences. The brackish waters of the estuary and the salt waters from the ocean invade the jungle, carrying dark mud in suspension, with floating stems of trees and fronds of ferns. Presently the mud subsides, and covers in one uniform sheet the accumulated vegetation of centuries. The process of subsidence goes on, while the sea-currents and rivers pour into the estuary fine sand and mud, in which branches and stems of trees from the uplands are included. This process continues until the sinking of the ocean-bed either altogether ceases, or is counterbalanced by the rapidity with which the sediment is deposited. The basin becomes gradually shallower, and the plants begin to re-appear, commencing perhaps at the coast, and creeping seaward, until the whole basin is again overspread by a forest of huge cryptogamic trees, arborescent ferns, and conifers. These, generation after generation, flourish and die; their leaves, branches, and trunks, falling around and gradually accumulating till the pulpy mass attains a thickness of 20, 50, or 100 feet. The process concluded, the basin again commences to subside, the waters return and bury the mass for hundreds of centuries; stratum after stratum accumulates, till the vegetable pulp is subjected to the pressure of, it may be, thousands of feet of solid matter. Meanwhile, chemical as well as mechanical changes ensue, and in process of time what was once a forest is changed into a bed of coal. By a repetition of this process, with local variations, we may conceive the formation of any number of coal-seams, amounting in some districts to fifty or sixty, and embraced within a vertical thickness of several thousand feet of shales, clays, and sandstones. Ages roll on, the strata are moved from their foundations; upheaved from the sea-bottom, the rains, rivers and currents sweep away a portion of the covering, and the mineral treasures are brought within the reach of mining industry." (Pp. 78-9.)

In this way the coal is formed; and in order to comprehend it, we may add the table given by Professor Hull of the formations over and underlying the coal measures, applicable to the whole of Britain.

Tabular view of the Trias, Permian, and Carboniferous Series in England and Wales.

New Red Sandstone or Trias.	Keuper.	Red marl. Lower Keuper Sandstone.
	Bunter.	Upper mottled Sandstone. Conglomerate beds. Lower mottled Sandstone.
Permian rocks.		Upper Red Sandstone of St. Bees, &c. Upper and lower magnesian limestones and marls of the northern counties. Lower Red Sandstone of Lancashire, Cumberland, Yorkshire, &c. (on the same horizon with) Red Sandstones, marls, conglomerates, and breccia of the central counties and Salop (*Rothe-todte-liegende*).
Carboniferous rocks.	Upper carboniferous.	Upper coal measures with spirorbis limestone and thin coal seams. Middle coal measures with thick coal seams.
	Lower carboniferous.	Lower coal measures or Gannister series, with thin coal seams and lower carboniferous fossils. Millstone grit, with thin coal seams. Upper limestone shale, or Yoredale rocks. Carboniferous limestone, with shales, sandstones, and coal in the northern counties and Scotland. Lower limestone shale.

Old Red Sandstone and Devonian rocks.

It is interesting to notice how vast a number of plants, known and unknown, must have contributed to the formation of coal in its present form; nor is it unimportant to observe what a natural conservation of force has thus gradually been prepared. Various forms of gas, as we understand the term, have thus been forming, pent up in a solid form or chemical base to be utilized in our generation, until higher methods of lighting can be attained by subtler processes. Garnered up in the recesses of the earth, unconsidered, were treasures of a material prosperity become so commonplace in our time as to be no matter of wonder at all. It is worse than idle to suppose that in the lighting and heating virtues of coal consist its sole blessing to many. The products of that jealously-guarded substance are being utilized in a thousand ways for the improvement of our dyeing and other manufactures; and, contrary to general opinion, we have little doubt but the producing powers of coal will be adequate to our want of it. Future generations will no doubt be supplied by electric or magnetic means; on this, however, in a purely practical sense, it does not fall in our way to opine. But we think we may safely conclude, with Professor Hull, that there is no reason to doubt of a continued yield from our coal-fields for three hundred years to come, and that a needless alarm has been raised on that head. Even if it should prove that the coal-fields of England and Scotland are likely to be exhausted within a period sufficient to alarm persons now interested in the yield per annum, it is certain that within the area of the British Empire new sources are continually being discovered. It will soon be possible for our colonies to provide themselves with coal from their own resources. Beginning with India, where Dr. Oldham and his staff of assistants have been long engaged in completing a coal survey, we find that there are very large tracts stored with coal in Northern India, principally in the valley of the river Damuda. Six districts are named by Professor Hull in his work, as follows:—

Name.	Area.
1. Raniganj . . .	1,000 square miles.
2. Karanpura . . .	472 "
3. Bokaro	220 "
4. Jherria	200 "
5. South Karanpura . .	72 "
6. Ramgurh . . .	40 "

To these may be added the coal-fields of Kurhurbari, Deoghur, Nerbudda, and Assam.

"The Damuda series consists," says Professor Hull, p. 353, "of three divisions, a lower, middle, and upper, and resemble in appearance the coal measures of England, being composed of sandstones and shales, with beds of coal and ironstone, probably of freshwater origin. Their actual geological age is, however, still a matter of uncertainty, owing to the absence of any organic remains except plants and a few reptiles of indeterminate age. Amongst the plants, however, the *Cycadaccæ* are the predominant forms, along with which are some genera, such as *Equisetum*, *Cyclopteris*, and *Sphenopteris*, which are found both in Palæozoic and Mesozoic deposits; and others, as *Voltzia*, which is Triassic; and *Brachyphillum*, which is Jurassic. The evidence is therefore conflicting; the abundance of cycads giving a Jurassic aspect to the flora, while the other forms belong to a more ancient period. All, therefore, that can be stated is that the coal formation of India is more recent than the carboniferous period of Europe, and is referable to some portion of the Mesozoic epoch.[1]

"*The Raniganj Coal-field.*—This is the most important coal-field in India, and seems destined to be of great economical value at no distant period. It lies at a distance of 120 to 160 miles N.W. of Calcutta, along the valleys of the Damuda and Adjai rivers. From the report of Mr. W. T. Blanford we gather that the strata containing coal attain a vertical thickness of about 12,000 feet, rising and outcropping towards the north, and in the opposite direction abruptly ending against the older crystalline rocks, along one of the largest faults on record, which ranges in a direction from east to west. There are numerous beds of coal, which were estimated by Mr. D. H. Williams (1847) to attain a combined thickness of 354 feet. This coal, though inferior to that of England or Wales, has been proved to be perfectly adapted for locomotive or stationary engines or for the smelting of iron; yet with such prodigious supplies, not more than half a million tons were raised in the year 1868 out of a total production for India of 547,971 tons.

"*Karanpura Coal-field.*—This coal-field is situated in the Damuda valley, between 84° 51′ and 85° 30′ E. long. and 23° 37′ and 23° 57′ N. lat., and covers an area of 472 square miles. From the report of Mr. T. H. Hughes, of the India Survey, it appears there are numerous seams of coal, giving a total vertical thickness of 35 feet, calculated to yield about 8,750 millions of tons. A specimen from the larger of the Gondalpura seams gave, on being assayed, the following results:—

"Carbon, 64·5; volatile matter, 27·0; and ash, 8·5. Iron ores, both clay, ironstone, and hematites, are abundant.

"*Bokaro Coal-field.*—This is the third in importance amongst the coal-tracts of the Damuda valley. From Mr. T. W. Hughes' report we find that it contains several seams of valuable coal from the 'Barakar bed,' capable of yielding about 1,500 millions of tons. The most valuable portion of this field lies between the river Koonar and the eastern boundary. Beds of ironstone are also present.[2]

"*Jherria Coal-field.*—This tract lies about 170 miles from Calcutta along the Damuda valley, and extends from east to west for a distance of eighteen miles; its greatest breadth is ten miles. Mr. Hughes,[3] in his report, states that in a series of beds of about 6,000 feet in thickness there are beds of coal having a combined thickness of about 80 or 100 feet, the thicker seams being in the lower part of the Damuda series. Some of the coal is of good quality, especially that of the 'Barakar beds.' Dr. Oldham estimates the possible yield of this coal-field at 465 millions of tons, and adds, 'Whatever the margin of error may be, the facts are sufficient to prove the existence of a very large amount of good fuel in this Jherria coal-field which at some future period will be found most valuable.'[4]

"*South Karanpura Coal-field.*—This little tract of coal-measures is separated from the larger field above described by a strip of metamorphic rocks.[5] In proportion to its extent, it appears to be even more productive than the larger field, containing as it does about 70 feet vertical of coal, and capable of yielding, according to the estimates of Mr. Hughes, seventy-five millions of tons of coals. Iron ores are also abundant.

"*Ramgurh Coal-field.*—This coal-field also lies in the Damuda valley, between the meridian of 85° 30′ and 85° 45′ E. long. From the report of Mr. V. Ball, it appears to have an area of about forty square miles. The coal in the eastern part of the district occurs generally in thick seams; but the quality is so variable, and there are such frequent alternations with bands of stony shale, that Mr. Ball forms a low estimate of the economic value of this portion. In the western extension of the field, where the seams are of better quality, they are much broken and crushed owing to numerous faults and flexures of the strata.[1]

"*Kurhurbari Coal-field.*—This coal-field is one of those which lie beyond the limits of the valley of the Damuda. The coal-beds are, however, referable to the 'Damuda series,' and from the superiority of their quality, and owing to their position with reference to the East Indian Railway, and the large towns west of Dinapore, are likely to become of great economic value. The area of the field is only eight square miles, and its general structure is that of a basin,[2] while some of the coal seams reach a thickness of 14 to 16 feet, but vary rapidly in this respect. Mr. Hughes estimates the yield of this tract at eighty millions of tons of available coal."

The Deoghur Coal-fields are of such limited extent as to merit no special notice, but the *Nerbudda Coal-field*, covering a considerable area of Western India, contains a vast quantity both of coal and iron ore. Very good seams have been observed and large supplies of coal can doubtless be obtained; the strata in which the coals occur belong to the Damuda series and the lower Tertiary era. Large quantities of coal are known to exist in Upper Assam, remarkably free from ash, as may be seen by the following statement respecting samples taken from three different localities ("Coalfields," p. 360):—

	Fixed Carbon.	Volatile Matter.	Ash.
Terap . .	61·8 . .	36·5 . .	1·7
Namchik .	50·4 . .	44·6 . .	5·0
Jaipoor . .	53·0 . .	43·3 . .	3·7

It is the expressed belief of Professor Hull that India may become a great manufacturing country; and there would appear no reason why cotton, grown, as it were, on the spot, should not also be manufactured without the expense of transport to this country. At a time when Russia—although we do not share the fears expressed by a great many persons in relation to her designs upon India—is consolidating her power in adjacent territories, we may well point to India and its resources as a worthy prize to maintain at the further cost of many millions.

Australia is also very rich in coal, and as population increases is destined to play a very considerable part in the world's history. The State of Victoria contains carbonaceous deposits of the best kind, while New South Wales is also rich in similar treasures. The Rev. W. B. Clarke, who published in 1860 a work entitled "Researches in the Southern Gold-Fields of New South Wales," states that, compared with the latter, the carboniferous portion of this territory is infinitely greater than it was supposed in the year 1847, about which time the gold discoveries took place.

The Australian Newcastle, lying on the Hunter River, affords equal facilities with the English emporium for loading up coal. The coal-fields lie on the sea-shore, some beds even cropping out upon the steep coast bluffs, so that they are visible from sea. The seams extend over an area of about six miles along the coast and twenty miles into the interior, having a thickness of from 3 to 30 feet.[3] The constituents are:—Carbon, 74·13 to 78·0; hydrogen and oxygen, 25·87; ash, 5·0; water, 1·6.

The whole country is pregnant with coal, and in the new colony of Queensland similar phenomena present themselves. Tasmania likewise contains extensive coal-fields, and New Zealand also is full of valuable coal-fields. If we add to this the fact that the United States, China, and other countries, contain supplies of an almost inexhaustible kind, the fear that mankind should be deprived of its important fuel becomes little better than an idle alarm, of which no further notice need be taken.

In a general review of Professor Hull's work it is impossible to leave out his views upon deep coal-mining, inasmuch as the ideas expressed in the first and second editions of his book have been adopted by the Royal Commissioners, and hence obtain an endorsement both authoritative and specially important to the mining interest.

"The reader," says Professor Hull,[4] "will have observed that the limit of depth adopted in the estimates of the workable quantity of coal in the individual coal-fields and adjoining districts has been 4,000 feet, notwithstanding that there are hundreds of square miles stored with coal at greater depths than this, which have been estimated by the Royal Commissioners to amount to no less than 48,465 millions of tons.[5] Now, it so happens that

[1] See the discussion of this question by Dr. Oldham, in "Mem. Geol. Surv. India," vol. ii.
[2] "Mem. Geol. Survey, India," vol. vi. part ii.
[3] Ibid. vol. 230.
[4] Ibid. vol. v. p. 336.
[5] Map accompanying the Report of Mr. Hughes. Ibid. vol. vii. part iii.

[1] "Mem. Geol. Survey, India," vol. vi. part ii.
[2] Mr. T. W. Hughes, ibid. vol. vii. part ii.
[3] Hochstetter's "New Zealand," p. 75.
[4] "Coal-Fields of Great Britain," pp. 422, *sqq.*
[5] The quantity obtained by adding the amount of 7,342,000,000 tons included in the known coal-fields to 41,144,000,000 tons in districts overspread by newer formations. Report, vol. i. pp. ix. and xvii.

the limit of 4,000 feet, which I adopted in 1860, on grounds stated in the first and second editions of this work, has also been adopted by the Royal Commissioners as the greatest depth to which mining operations are ever likely to extend. This concurrence of views on a subject bearing so directly upon the question of the exhaustion of our coal resources is gratifying to myself, and will probably be regarded by the public at large as a ground of confidence in the conclusions arrived at by me and the commissioners.

"The two main impediments to the prosecution of mining operations at great depths are the increase of temperature in the strata themselves, and of the pressure due to the weight of the strata; but as the latter obstacle is capable of being overcome in most cases, especially under the 'long-wall system' of mining, it may be omitted from consideration;[1] and we may concentrate our observations on the subject of increase of temperature alone.

"That the temperature of the earth's crust increases as we descend from the surface is a question which has been determined in the affirmative by observations extending over a large portion of the land surface itself. It is, however, to be observed that, compared to the radius of the earth, these observations reach only a very small depth; nevertheless, they are perfectly sufficient for determining the problem, as far as it is calculated to influence the question of deep mining; and, in order to put the reader in possession of the evidence as derived from direct observation, the following cases of special interest may be here cited:—

"The first of these is the experiment at the Puits de Grenelle, near Paris, the particulars of which are stated by Arago and Humboldt.[2] The water ascends from the greensand formation, which outcrops at Lusigny, south-east of Paris. The depth of the well from the surface is 1,903 English feet, and 1,675 feet below the level of the sea. The temperature of the spring is 81·95 Fahr. and the rate of increase is 1° Fahr. for every 58·9 English feet.

"At Neu Saltzwerk, in Westphalia, a boring was commenced at a height of 232 feet above the level of the sea, and it reached an absolute depth of 2,285 feet. Its temperature is 91° 04′ Fahr. and as the mean annual temperature of the air at Neu Saltzwerk is about 49° 28′ Fahr. we may infer an increase of temperature of 1° for 54·72 English feet, or 1° Cent. for 92·4 Paris feet. The boring of the well at Neu Saltzwerk, as compared with that of Grenelle, has a greater absolute depth by 491 French or 523 English feet, and a greater relative depth below the level of the sea of 354 French, or 377 English feet; and the temperature of its water is 5° 1′ Cent. or 9° 18′ Fahr. higher. The rate of increase of temperature in the shallower well at Paris is nearly 1-14th less rapid than in the deeper well at Neu Saltzwerk. This observation is important, as it is sometimes supposed that the rate of increase diminishes in a constant ratio as the depth increases.

"Near Geneva, an artesian boring, to a depth of 724 English feet, gave an increase of 1° Fahr. for every 55 feet. The locality is at an elevation of 1,600 feet above the level of the sea.

"At Mondorff, in the Grand Duchy of Luxemburg, an artesian boring of great interest, owing to the number of formations through which it penetrated, gave a result of 1° Fahr. for every 57 feet. The details were as follows:—

	Metres.
Lias	54·11
Keuper (red marls, &c.) . . .	206·02
Muschelkalk (limestone) . . .	142·17
Grès begarré (sandstone) . . .	311·46
Old schistose rocks . . .	16·24
Total . . .	730·00

"An extensive series of experiments carried on in the mines of Cornwall by Mr. R. W. Fox,[3] has induced that gentleman to arrive at the conclusion that the increase of temperature progresses in a diminishing ratio, and Mr. R. Hunt adopts a similar view, founded on observations in the same district. Difficult as it is to conceive, and far more to account for such a result, which would appear to show that as we approach the source of the heat the heat itself decreases, yet it cannot be denied that the results obtained by these observers (if taken by themselves) seem to favour the conclusions at which they have arrived. The following is a synopsis of Mr. Fox's experiments:—

A temperature of 60° at 59 fathoms below the surface.
" 70° at 132 " "
" 80° at 239 " "

Being an increase of—

10° at 59 fathoms deep, or 1° in 35·4 feet.
10° at 73 fathoms deeper, or 1° in 43·8 feet.
10° at 114 fathoms still deeper, or 1° in 64·2 feet.

[1] The Report of the Coal Commission scarcely alludes to this subject, and it is probable that the commissioners did not consider it necessary seriously to entertain it.

[2] "Cosmos, Sabine's Transl." vol. iv. p. 35.

[3] "Report of British Association," vol. ix.

The deepest observations were taken in the Tresavean mine in 1837, at the following depths:—

262 fathoms, 1,572 feet, 82·5°
290 " 1,740 " 85·3°
Same depth in another lode, 86·3°
" " in a third lode, 92·1°
Mean temperature for 1,740 feet, 87·9°

Mr. Hunt has found the temperature as high as 100° at a depth of 320 fathoms in this mine.

"Allowing due weight to opinions coming from these observers, I cannot accept as of universal application an hypothesis of the increase of temperature in a diminishing ratio. It does not appear to be in harmony with the results obtained on the Continent, where the increase of temperature in the deeper well of Neu Saltzwerk is 1-14th more rapid than in the shallower well of Grenelle. Nor can it be reconciled with the observations in Dukinfield Colliery (about to be given in detail), where the increase on the uppermost strata, down to 270 yards, is 1° for 88 feet, and on the lowest, down to 685 yards, 1° for 65·6 feet. Professor Phillips has made observations on the temperature at the Monkwearmouth Colliery which have shown an increase of about 1° for every 60 feet.

"*Dukinfield Colliery.*—The experiments lately carried out by Mr. Astley, during the progress of sinking the Dukinfield Colliery, are perhaps the most valuable of any hitherto undertaken in this country. Through the kindness of Dr. Fairbairn of Manchester, I have been supplied with the whole of the details, which I here insert with great care. The thermometer was inserted in a dry bore-hole, and removed as far as possible from the influence of the air in the shaft, and left in its bed for a length of time, varying from half an hour to two hours. The results also carry with them more than usual importance, from the fact that they extend downwards to a depth of 2,055 feet, with an additional observation made in the open workings at 120 yards from the shaft, and at a depth of 2,151 feet.

Thermometrical Observations in the Dukinfield Colliery, Cheshire, between 1848 *and* 1859.

Date.	Depth in yards.	Temperature, Fahr.	Description of Stratum.
1848.			
July 28	5·6	51	Red rock, no variation
1849.			
" 1	231	57·7	Blue shale, wet
" 13	234·7	58	" dry hole
" 16	237	58	" "
July 14	239	57·5	" "
" 16	240	58	" "
" 27	242	57·5	" "
August 9	244	58	" "
" 25	248	58	" water
" 27	248	57·25	" "
" 31	250	57·25	" "
November 14	252	58	" "
December 6	256·5	58	Blue shale, dry
" 15	262·5	58·5	" "
" 22	270	58	Bituminous shale, dry
1850.			
January 9	279	58·5	Strong warrant earth
" 26	286·5	59·12	Rock bands
February 11	293	59·5	Coal roof
" 19	300	59·87	Warrant earth
March 5	309	59·87	Purple mottled shale
1851.			
June 9	358	62·5	Warrant earth
August 14	373	64	Tender blue shale
November 7	403	65	Coal roof
" 19	419	65·37	Rock bands
1852.			
February 6	433	66·5	Black shale
May 28	446	67	Strong fireclay
1857.			
February 28	483·5	67·25	Sandstone, dry hole
March 7	487	67·76	Shale
April 11	501	68·5	Sandstone
May 6	511·5	68·75	Blue shale
" 19	521·5	69·38	Strong shale
June 9	533	69·75	Warrant earth
" 22	539	69·88	Blue shale
" 27	546	71·75	Coal and earth
July 18	555	71·25	Grey sandstone
August 1	563	72·25	Redrock (sandstone)
" 15	569	71·25	" wet hole
September 2	578	72·12	" "
" 19	589	71·5	" "
October 3	597	72·25	Grey rock, dry hole
" 17	608	72·25	Coal roof, wet hole
" 27	613·5	72·25	Coal floor "
1858.			
March 22	621	72	Strong shale, dry
" 29	627	71·5	Dark blue shale
April 23	645·5	72·25	Shale, dry hole
May 1	651	72·25	" "
" 19	658	72·5	" "
June 9	669	73·25	Bituminous shale, dry hole
" 19	673	74·12	Grey rock
July 17	683	75·25	Blue shale
" 21	685	75·5	"
1859.			
March 5[1]	717	75·0	"Black Mine" coal root.

[1] In workings at 120 yards down engine incline from the shaft.

"1. The first observation gives 51° as the invariable temperature throughout the year at a depth of 17 feet.[1] Between 231 yards and 270 yards the temperature was nearly uniform at 58·0, and the increase from the surface would be at the rate of 1° Fahr. for 88 feet.

"2. Between 270 and 309 yards the increase was at the rate of 1° for 62·4 feet.

"3. Between 309 and 419 yards the increase was at the rate of 1° for 60 feet.

"4. Between 419 and 613 yards the increase was at the rate of 1° for 86·91 feet.

"5. Between 613 and 685 yards the increase was at the rate of 1° for 65·6 feet.

"6. The last observation, taken in the mine itself at 120 yards from the pit, is valuable, as showing that the temperature of the air does not greatly differ from that of the surrounding strata.

"The result of the whole series of observations (making allowances for the doubt regarding the first observation) gives an increase of about 1° for every 80 feet, which is a less rapid increase than that exhibited by the generality of experiments. But before discussing the cause of this abnormally slow rate of increase, I wish the reader to become acquainted with the experiments of not less interest and value made at another colliery near Wigan, and extending to a still greater depth.

"*Rose Bridge Colliery, Wigan.*—The following observations on the temperature of the strata during the progress of sinking the pits of Rose Bridge Colliery, at Ince, near Wigan, now the deepest mine in England, have been communicated to the author by Mr. Bryham, the manager, by whom they were carried out. They differ materially from those of Dukinfield, just described.

Thermometrical Observations at Rose Bridge Colliery.

Date.	Depth in yards.	Strata.	Temperature in open pit.	Temperature in solid strata.
			deg. Fahr.	deg. Fahr.
July, 1854	161	Blue shale	—	64·5
August, 1854	188	Warrant earth	—	66
May, 1858	550	Blue shale	—	78
July, 1858	600	Warrant earth	—	80
May 18, 1868	630	"Raven" coal	73	83
July 24, 1868	665	Strong shale	73	85
April 19, 1869	673	"Yard coal" mine	76	86
November 18, 1868	700	Strong blue metal	76	87
February 22, 1869	736	Do. do.	76	88½
March 12, 1869	748	Shale	77	89
April 17, 1869	762	Linn and wool or strong shale	78	90·5
May 3, 1869	774	Strong shale	80	91·5
May 19, 1869	782	Blue metal	79	92
July 8, 1869	801	Strong blue shale	79	93
July 16, 1869	808	Coal (Arley mine)	79	93½

"Assuming the surface temperature to be 49°, we have on the whole depth of 815 yards, or 2,445 feet, an increase of 45°, which is at the rate of ·0184 of a degree per foot, or one degree for every 54·3 feet, as against one degree for every 80 feet at Dukinfield. . . . . With strata so nearly similar, and in two neighbouring counties, we should scarcely have expected so much difference in the mean rates of increase downwards. In this respect Rose Bridge agrees nearly with the average results obtained elsewhere; Dukinfield far surpasses all other deep mines or wells, so far as our present records extend, in slowness of increase.

"In a paper published in the proceedings of the Royal Society of London, I have endeavoured to show that the cause of the discrepancy in the results obtained at the two localities is due to the differences in the position of the strata in each case. At Rose Bridge the beds are nearly horizontal; at Dukinfield they are inclined at an angle varying from 30° to 35°, rising and cropping out to the eastward. Now, strata of various kinds, such as alternating sandstones, shales, clays, and coal, with different conducting powers, must offer more resistance to the transmission of heat in a direction across than parallel to their planes of bedding; for Mr. Hopkins has shown that every sudden change of material is equivalent to an increase of resistance; and it is obvious that highly inclined strata, such as those at Dukinfield, furnish a path by which internal heat can travel obliquely upwards and outwards, without being interrupted by these breaches of continuity. On the other hand, deep-seated horizontal strata, like those of Rose Bridge, offer a succession of resisting surfaces to the upward passage of internal heat.

"As, therefore, the rate of increase of temperature is inversely proportional to the upward flow of the heat, we have here a solution of the results arrived at in the cases before us.[1] To this may be added, that inclined strata furnish great facilities for the convection of heat by the flow of water along the planes of junction.

"The general inference which may be drawn from the cases just described, as far as they bear upon the temperature of coal-mines, is this: that in those districts where the strata are highly inclined (at angles varying from 30°—60°) the underground temperature will be less than in the case of those where the strata are in a position approaching the horizontal.

"*Mean result.*—The illustrations already adduced will probably be considered sufficient to show that the increase of temperature is a reality, which becomes a sensible obstacle at a slightly variable depth, and will have to be encountered and overcome by artificial means when the depth exceeds 800 or 900 yards. On this point the Commissioners on Coal Resources have arrived at the conclusion that at a depth of 1,000 yards (3,000 feet) the temperature of the earth would amount to 98°. Under the 'long wall system' of working, a difference of about 7° appears to exist between the temperature of the air and that of the working faces, and this difference represents a further depth of 420 feet; so that the depth at which the temperature of the air would under the present conditions become equal to the heat of the blood would be about 3,420 feet. Beyond this point the considerations affecting increase of depth become so speculative that the commissioners leave them in uncertainty; but they consider it may be fairly assumed that a depth of at least 4,000 feet may ultimately be reached in coal mining."

We shall now close our extracts from Professor Hull's valuable work by referring again to the article by Professor Leone Levi in our former number. So much of the subject is there so tersely and ably treated that the writer found himself quite anticipated upon almost every topic embraced under the general head of the coal question. Perhaps one of the best recommendations of Professor Hull is contained in the last paragraph of the fourth part of his work, where, after discussing *in extenso* the question of waste, he addresses himself to the subject of education on the part of colliery supervisors. He says (and we heartily re-echo his words, with which we shall conclude this article):[2]

"It therefore becomes a matter for consideration whether the Legislature should not establish some educational test, without which no person should be permitted to have the supervision of a colliery, as far as the actual working arrangements. The schools of mining which have been founded in various districts offer suitable opportunities for the necessary training, as also some of the educational establishments under the Science and Art Department; but, unless the compulsory principle be introduced, experience has shown that the advantages offered by such institutions will not be fully seized by the mining population."

[1] This observation for the position of the invariable stratum is probably not reliable. The depth ought to be greater, but its accurate determination requires a series of observations which could not well have been made in the present instance.

[2] These observations, with a complete section of the strata to a depth of 815 yards from the surface, are given in the "Third Report of the Committee on Underground Temperature," Rep. Brit. Assoc. 1870.

[1] "Proceedings of Royal Society," 1870, vol. xviii. p. 175.

[2] Hull, "Coal-Fields," p. 458.

THE NICKEL-SEATED SAFETY-VALVE.

Chief Engineer's Office,
Washington, *December* 2, 1872.

Rear Admiral L. M. Goldsborough, U. S. N., Commandant.

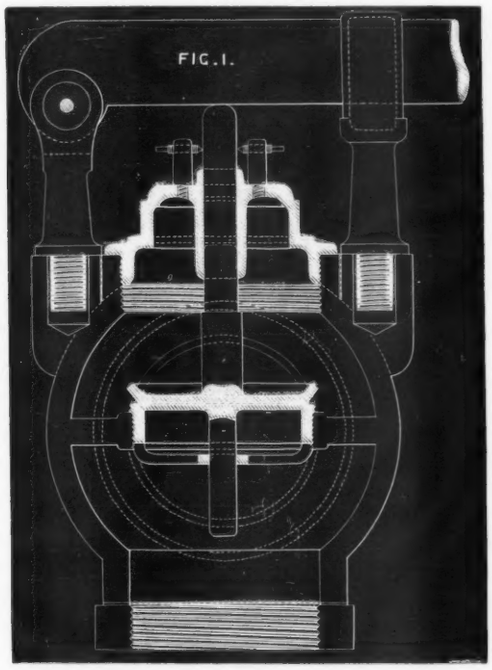
SIR—In obedience to your order of September 12th, 1872, to test the "Nickel-Seated Safety-Valve," manufactured by E. H. Ashcroft, of Boston, Mass., and report upon its advantages and disadvantages, I beg leave to submit the following:—

The boiler used for the test was of the cylindrical horizontal tubular type, six feet in diameter, twenty feet long, grate surface twenty-two square feet, heating surface nine hundred and twenty-eight square feet, and of about thirty nominal horse-power. Pressure of steam used in the test from sixty-five to eighty pounds per square inch.

The experiments were comparative, and were made with seven valves, of the common kind, of the following diameters, viz.: 4″, 3″, $2\frac{9}{16}$″, 2″, $1\frac{3}{32}$″, $1\frac{1}{32}$″ and 1″, and seven of the nickel-seated valves, of diameters 4″, 3″, $2\frac{1}{2}$″, 2″, $1\frac{1}{2}$″, $1\frac{1}{4}$″ and 1″. The object was to ascertain the lift and area of opening given for the escape of steam when the valve was acting freely and blowing

off at full pressure of steam, and to ascertain how much the pressure could be increased after the valve was in full operation. The lift was ascertained by securing scratchers against the valve stems. The results can be seen by referring to the accompanying diagrams. The outer circles represent the circumferences of the valves. The areas of the inner circles represent an area equal to that given for the escape of steam by the circumference and full lift of the valve when blowing off at the limit of pressure.

In these respects the nickel seated valve possesses an advantage which places it beyond comparison. The 4″ common valve, when blowing off at the limit of pressure, had a lift of $\frac{1}{30}$ of an inch, giving an area for the escape of steam of $\frac{63}{100}$ of a square inch. The nickel seated valve of the same diameter, operating with the same pressure, had a lift of $\frac{1}{4}$ of an inch, giving an area for the escape of steam of 3·14 square inches. The 3″ common valve had a lift of $\frac{1}{17}$ of an inch, giving an area of opening of $\frac{56}{100}$ of a square inch, while the 3″ nickel seated valve had a lift of $\frac{3}{16}$ of an inch, giving an area of opening of 1·76 square inches. In the experiment to ascertain how much the pressure could be increased while the valve was blowing off at the limit of pressure, with the 4″ common

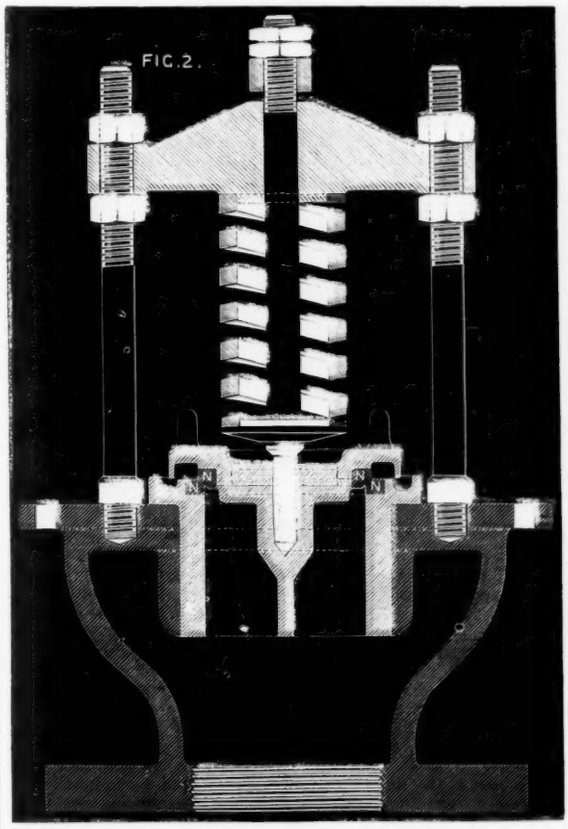


valve, which is about the diameter used on boilers of the size mentioned, the pressure was increased five pounds in four minutes, without any apparent increase in the lift, and the experiment was stopped. With the 3″ valve the pressure was increased nine pounds in six minutes. The 4″ nickel seated valve operating under the same circumstances opened to its full lift as soon as the limit of pressure was reached, and the pressure could not be increased, but it steadily decreased to a point a little below the original pressure, when the valve suddenly closed. With the 3″ valve the pressure was held at the limit of pressure. In both cases the fires were in active condition and the furnace doors closed.

This experiment proved that the lift of the common valve is not sufficient, and will not increase with the pressure, by its own action, sufficiently to relieve the boiler under all circumstances, and that the pressure can be increased until an explosion takes place, while the valve is in operation, and therefore it is not, in reality, a safety valve.

The nickel seated valve, under the same conditions, obtained its full lift instantaneously by its own action, giving an opening of sufficient area to relieve the boiler at once.

The common safety valve needs no description. The nickel seated valve is automatic, and can be used either as a lock-up or an open valve. It is actuated in its resistance to the steam pressure by a spiral spring of the most accurate workmanship, and plated with nickel. The face of the valve coming in contact with the seat is composed of a solid ring of nickel. The valve seat is also of solid nickel. The qualities of this metal form one of the most important features in this valve. Its great hardness insures its resistance to wear. It is not affected by the action of steam and the saline matter in water, and, being non-corrosive, it is free from the possibility of sticking, as is often found to be the case with the common valve, by corrosion, and which may be attended with the most fearful consequences. The valve is constructed with a curved lip, as seen in the accompanying drawing, so that the main body of the steam, as it escapes from the boiler, being directed downward, strikes against the bottom of a suitable recess surrounding the valve seat, and the recoil of the steam acting upwards against the under surface of the valve as it issues into the atmosphere assists the valve in obtaining a higher lift. This action is sure and instantaneous, and it was found that the greater the steam pressure the higher the lift, using the same spring. For instance, with a 3″ valve, the spring being set to open at sixty pounds, the valve will lift full $\frac{1}{8}$ of an inch, and with the same spring set to



open at eighty pounds, the lift will be $\frac{3}{16}$ of an inch. The lift of the common valve will remain the same at any pressure, the weight on the lever being adjusted to the given pressure as in the case of the spring. For instance, if the weight is adjusted to yield to a pressure of twenty-five pounds, the lift of the valve will be about $\frac{1}{32}$ of an inch, and if adjusted to a pressure of eighty pounds, and raised by the steam, the lift will be the same.

The late experiments at Sandy Hook, N. J., on steam boiler explosions, have disposed of many old theories regarding this subject, such as electricity, formation of gases, the sudden generation of steam of an enormous pressure, &c., &c., and have proved that explosions of the most destructive character can occur by the gradual accumulation of steam and with the moderate pressure of fifty-three and one-half pounds per square inch.

It was also observed that it required but thirteen minutes to raise the pressure from thirty pounds, the working pressure allowed for this boiler, to fifty-three and one-half pounds, when it was torn into fragments, and a part of it, weighing three tons, was hurled four hundred and fifty feet from its original position, showing that the neglect of only a few minutes, together with an inoperative or inefficient safety valve, are all that are required to produce the most frightful results.

The subject of safety valves, heretofore so much neglected, is receiving considerable attention in England and elsewhere, and the experiments made with the common valve corroborate some of the above statements. Under whatever circumstances explosions may occur, the real cause is excessive pressure, and the fact that such disasters do occur, whether from neglect or otherwise, involving fearful loss of life and property, points forcibly to the necessity of providing against them in every possible way, and the only safeguard that can be applied to a steam-boiler is a safety valve that is automatic, certain in its action, prompt in opening and closing at the required moment, and that can be fully relied upon to relieve the boiler under all circumstances.

It is impossible to provide against the contingent dangers of a steam-boiler, such as the hidden imperfections of the iron, the chemical action to which they are subjected, &c., but for the prevention of any pressure in excess of that allowed, I am fully of the opinion that the "Nickel Seated Valve" is the only one that fulfils the requirements.

Very respectfully your obedient servant,

EDWIN FITHIAN,
Chief Engineer, U. S. N.

CRAMPTON'S COALDUST FURNACE.[1]

FOR some time past there has been at work in the Royal Gun Factories, Woolwich Arsenal, a furnace upon an entirely novel principle, and which embodies some very remarkable features. To the outer world this furnace has been more or less a mystery, no information being obtainable respecting it further than that it was burning coaldust mixed with air. To the authorities of the Arsenal and a few scientific gentlemen, however, it has been known that the furnace and its working involved the solution of two of the most important questions of the present day—namely, the utilization of waste coal, and the perfect combustion of fuel without smoke. These two questions date back to the earliest discovery of coal, and never, probably—except experimentally—have they been satisfactorily solved apart, certainly not in combination. The utilization of coaldust has been attempted over and over again in many forms of patent fuel, in which it has been mixed with clay, tar, pitch, lime, &c., these attempts having been attended with varying degrees of success. In this, however, modern inventions are not original, inasmuch as the Chinese have been accustomed for ages to mix their coaldust with a compost of soft clay, just sufficient to make it cohere, the balls being dried in the air and forming a very useful fuel. But coaldust, pure and simple, has never been successfully burnt alone, although several attempts have been made in that direction, and it has been left for Mr. T. R. Crampton—a gentleman whose name has long been well known in connexion with the locomotive engine, and who laid the first submarine telegraph cable between Dover and Calais—to demonstrate, in the furnace at Woolwich, the double fact that it could be so burnt, and that with it perfect combustion could be attained.

It need hardly be said that such a result has not followed as a matter of course upon the inspiration of the moment, nor that it has been arrived at without patient investigation and a long course of practical research. On the contrary, at least five years have elapsed since Mr. Crampton even thought out the process in its first crude form, during which period he has developed it, step by step, from an idea into the accomplished fact which to-day finds it. It has been worked out at the expense of much close study and careful thought, has been attended by many temporary failures, and has involved from first to last the consumption of between 2,000 and 3,000 tons of coal in different furnaces in various parts of the country. The Crampton furnace formed the subject of an important paper and discussion at the recent meeting of the Iron and Steel Institute. Its action depends upon the introduction, under pressure, of atmospheric air and coaldust, in carefully adjusted proportions, and so commingled and delivered at a precise and undeviatingly fixed point, as that not an atom shall pass unconsumed. This completeness of combustion depends upon the proper admixture of the surcharged and undercharged currents of air and powdered fuel. To follow Mr. Crampton through the various phases of reasoning and experiment by which he has perfected his invention might prove tedious and would serve no practical purpose here. It will suffice to take the invention as it now is, and to describe successively its principles, its construction, and its practice.

The principle of the Crampton furnace consists in the introduction of streams of air and powdered coal, mingled together, into a combustion chamber, in which they are united and burnt, the products of combustion passing into a chamber beyond, where the heat is utilized. As already intimated, attempts have been made to work out this principle in practice, but they have failed from various causes. In some cases the refractory material composing the combustion chamber has been rapidly destroyed by the streams of fuel and air impinging upon it. In others the fuel has not been reduced to a sufficient degree of fineness, nor properly mixed during its transit through the furnace, while in others, again, no efficient means have been provided for regulating the streams of air and fuel. Above all, the necessity of counteracting the tendency of the particles of fuel to separate from the air in no case appears to have been recognized. But unless provision is made to prevent the separation of fuel and air no good can be expected to result, inasmuch as the separated particles will either be deposited unconsumed, or only partially consumed, in the combustion chamber, or in the working chamber, or will be driven forward into the flue of the furnace. With all these difficulties Mr. Crampton has had to deal in developing his system, and one by one he has succeeded in overcoming them.

Two results only have hitherto been referred to as accruing from this invention—the utilization of coaldust and the perfect combustion of fuel. There is, however, a third, and equally important, question, which has received solution by the same means—that of mechanical puddling. This was the last fact accomplished, and it has imparted additional interest to the invention, and has given it a still higher value. This final improvement grew out of the last difficulty with which Mr. Crampton had to contend—namely, the preservation of the brick interior of the combustion chamber. The system was at first applied to an ordinary reverberatory puddling furnace, the fireplace of which was converted into a combustion chamber by covering the firebars with a layer of refractory material. This soon became coated with a film of flux which preserved it from the destructive action of the impinging streams of fuel and air; but the roof of the chamber over the bridge, where the intense heat was deflected, was acted upon and in time destroyed. It then occurred to Mr. Crampton that if he presented the whole surface of the chamber to the action of the flux, every part would be equally preserved. To do this it was only necessary to make the furnace revolve upon a horizontal axis, which would at the same time secure the important benefits derivable from mechanical puddling. There yet remain to be noticed two other practical results which have been achieved by Mr. Crampton in the furnace under notice. On the one hand, he has perfected a mechanical system of supplying the fuel to the furnace by self-acting apparatus, and on the other he has abolished the smoke nuisance. This latter result follows, as a matter of course, from all the rest, inasmuch as the only conditions under which the furnace can be successfully worked are exactly those which render the production of smoke impossible. To sum up: the furnace at Woolwich demonstrates the use of powdered fuel in a free condition, perfect combustion, mechanical puddling, self-acting feeding, and smoke consumption, to be accomplished facts. But, what is more, these facts are accomplished in one and the same apparatus.

The furnace by which these results are obtained stands in the Forge Department of the Royal Gun Factories. Near it, and placed in a corner of the building, is the machinery for reducing ordinary waste coaldust to a state of fine powder, which is done by grinding the dust between a pair of common mill-stones, and afterwards passing it through sieves of the required degree of fineness. It is found that the greatest amount of useful effect is obtained from fuel which has passed through sieves having 900 meshes to the square inch. From the sieves the fuel, which costs about 1s. per ton to prepare, is conducted by an archimedean screw to the feeding apparatus, which consists of a square chamber or hopper having two revolving stirrers so arranged at the bottom that the whole area of fuel is kept in a state of gentle agitation. These stirrers force the fuel through a horizontal opening in the front of the hopper on to a pair of rollers of different diameters, placed with their axes one above the other in a nearly vertical line. By this means a continuous and unvarying supply of fuel is delivered into an annular tube, leading into the furnace, and at a point where it is taken up by an induced current of atmospheric air. Both the supply of fuel and the supply of air can be regulated with the utmost nicety and precision according to requirement. The induced current of air is produced by a fan placed near to the furnace. The annular tube is fixed to the revolving furnace, while within it pass the pipes through which the water is circulated for keeping

[1] Report in the "Times."

the furnace itself cool on the outside. These pipes lead the one from a water tank to the casing of the furnace, and the other from the casing to a waste-pit. The water at the point of exit has a temperature of about 80 deg. Fahrenheit. The furnace itself is externally an iron cylinder, about 12ft. long and 7ft. in diameter, revolving about a horizontal axis, upon four bearing wheels let into a bed-plate on the ground. Around the furnace, at one end, is a toothed wheel, which gears into a pinion connected with a small engine—a steam winch, in fact, with a pair of 5-inch cylinders and 10-inch stroke—by which it is made to revolve. The interior of the furnace is divided into two parts midway of its length, the first part, or that into which the air and fuel are delivered, forming the combustion chamber, and the second part being the working chamber in which the iron is puddled. Communication is maintained between the two chambers through a circular opening in the division piece, or bridge, as it is termed. In some adaptations of the principle combustion is effected in the working chamber itself. The interior of the furnace is lined with firebrick, to which the slag from the iron melted in the furnace forms a protective covering. As the furnace revolves the molten slag is evenly distributed over the interior, the lining of the working chamber being further protected by the fettling used. This fettling consists of mill-tap, which is taken from the bottom of the coil furnaces in the Royal Gun Factories, and contains about 50 per cent. of iron. At the end of the working chamber is an iron flue leading to the chimney, and which is arranged with a counterbalance weight so that it can be removed from the mouth of the working chamber when necessary for the introduction or withdrawal of a charge. This flue piece is also lined with firebrick and is double, so that a stream of water is constantly passing between the inner and outer casing, thus keeping the exterior perfectly cool.

The principles of the Crampton furnace having been stated and its construction described, it now only remains to refer to its practical working. The furnace is started by lighting a fire of wood in the combustion chamber, and when a sufficient degree of heat has been developed, the air and coal are admitted in suitable proportions into the combustion chamber through the central opening at one end. The flames which they produce pass into the working chamber, and from thence the products of combustion are led by an opening at the end of the chamber into the flue and away out to the chimney. The charge of iron—about 5 cwt. at each heat—is introduced at the front end of the chamber, the flue being easily removed and replaced for the purpose, and when the heat is ready for removal the flue is again withdrawn. The iron used at the Arsenal is cast-iron scrap, such as old shot and shell, &c. The furnace has been working for some time past, and it is found that eight heats or charges of 5 cwt. each can be turned out in one shift of 12 hours. This is effected by melting the iron in the furnace itself; but Mr. Crampton proposes to melt the metal first in another furnace, when it is anticipated that 10 or 12 charges of 12 cwt. each will be worked off in the same time. A cupola has, in fact, been erected near the furnace, but has not yet come into regular use. The attendants required are only one skilled puddler with a helper at the engine, one man at the coal grinding apparatus, and a few extra hands when drawing the heats. With regard to the cost of production, the time of working has not yet been sufficiently long to afford reliable data upon that point, although it is clear that a considerable economy has been absolutely established. Approximately the consumption of coal-dust may be taken at $4\frac{1}{4}$ cwt. per hour. There are no renewals of furnace linings, as the slag and fettling protect them most perfectly, the fettling being renewed after each heat. During the operation of puddling, and when the furnace is at its fiercest, the outside remains perfectly cool, owing to the circulation of the water around it. In rotating it also, the little engine sends it round very smoothly—more smoothly, in fact, than it would seem possible for such a mass of iron to be revolved.

With regard to the results of working with this apparatus, it may be observed that in the ordinary furnace the loss in the yield of iron ranges from 6 to 10 per cent., while in this furnace there is a gain of from 5 to 10 per cent. This gain, of course, results from the use of mill-tap as fettling, the iron from which is melted out and runs into the general mass. The quality of the metal from the old furnaces, after being puddled, welded, and rolled three times, is such as to enable it to stand a tensile strain of about 22 tons per square inch, with a certain amount of extension before fracture. With Mr. Crampton's furnace it is found that, with re-heating the puddled ball once only and rolling it, practically the same extension before breaking is obtained, while the tensile strain is never under 23 tons, and is frequently as high as 26 and 28 tons per square inch. When this iron was hardened samples broke at 39 to 46 tons to the inch respectively, the iron retaining the true character of fracture and extension, and being of a far higher quality than that produced by the ordinary system.

The whole arrangement and working of the apparatus cannot be regarded otherwise than as most simple and effective. The distribution of a constant stream of water over the whole exterior surface of the furnace keeps the outside very cool, thereby avoiding distortion by undue expansion or contraction. The furnace is worked with a *minimum* of power, and at a *minimum* of cost both as regards labour and maintenance. It is to be observed that the system is not confined to puddling furnaces, but can be adapted to suit any requirement. Either land or marine boiler-furnaces or reverberatory furnaces can be fitted upon Mr. Crampton's principle. During its development at Woolwich considerable interest has been evinced in the coaldust furnace by the officials, Colonel Campbell having originally investigated the matter and induced the authorities to allow the invention to be worked out in its present advanced form. No pains have been spared by Colonel Campbell to promote the objects of the inventor in bringing the coaldust furnace to a successful issue. Mr. Fraser has also been unremitting in his exertions to further the same end. That the furnace has proved a success is in some measure due to the facilities afforded by the heads of the Royal Gun Factory, the working of which department, as regards efficiency and economy, is not surpassed at any private works in the kingdom.

Such, then, is the Crampton coaldust furnace as at present applied successfully to the puddling of iron at Woolwich. It will doubtless prove the forerunner of many more applications in the same direction, and there appears to be no reason why this system of burning coaldust should not, in course of time, be adopted in other directions where the production of high and even temperatures in an economical manner without smoke is a desideratum.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(40.)

DESIGNS for Ornamental Woodwork and working Lines and Centres.—In fig. 163 we give the design of a cut-wood railing or balustrade. Let *a b* be the height; divide this into two equal parts in the point *c*, through *c* draw a line at right angles to *a b*, as *d c d*. Divide the distance *a b* into eighteen, or *a c* into nine equal parts. With one of these from the centre *c*, describe the circle *e f g h*, and from the point where this cuts the lines *a b*, *d d*, describe circles, the radius of which is one-fourth of one of the parts, on *a c*. Then with the distance, as *h g*, from these points as centres, describe arcs cutting in the point *i*; from *i* as a centre with *e*, the same radius still kept on the compasses, describe an arc *j*. Do the same from the other points, as *g f*, *f e*, *e h*, and thus find centres from which the arcs corresponding to *j* are described. From the points *k* and *l*, where the outside of the small circles *e* and *g* cut the line *d d*, as centres with *i j* or *c g* as radius, describe arcs, as *l r s* or *u q v*, stopping at lines *n m*, *o p*, drawn through the points *k* and *l* parallel to *a b*. Next, from *i* set off to the point *p*, and do the same at the other and corresponding points, thus finding the four centres *m*, *n*, *o*, and *p*. From these, with *e c d* or *i j* as radius, describe arcs which are joined by straight lines with the semi-circles *w* and *x*, at the upper and lower ends of the design. To find the centres of these semi-circles, divide the distance between the points 1 and 2 on the line *a b* into four equal parts, and at the points draw a line as *z z*; from the point *y* set-off in the line *z z* a distance equal to *b g* to the points *a'* and *b'*. From these points *a'* and *b'*, with a radius equal to *y* 1 or *y* 2, describe semi-circles, as *w c'*, *x c'*. Join the points *w* and *x* by straight lines *e' e'*, with the arcs described from the points *p* and *n*. From a point in the centre between *b'* and *c'* and *a'* and *c'*, describe a small arc, and join this with another arc with the points, as *d'' d''*; the centre of these arcs being at *c' c'*. The lower arc *d'' f'* is described from the centre *g'*, which is on a line drawn through a point the third in the distance *b* 1 on the line *b a*. To describe the part marked A, cut out of the part B B. From the points *m o*, and *n* and *p*, describe small circles, the radius being one-fourth part of one of the parts on *a b*. With a radius equal to half of one of the parts, as 1 2 on the line *a b*, describe circles from the points *j' j'*, *k' k'*, leaving a space between them equal to the space at C, as *l' l'*, and with a radius equal to the diameter of these circles, describe from the points *l' l'* the arcs *m' n'*, *m' n'*. From *n' n'*, which are equidistant from the centre line, a space equal to the

radius of the small circles *u p*; describe with radius of these small circles the arcs meeting in the point *o'*. With *w v* or *s t* as radius, set off in the line *h' h'*; from the points *l' l'* to *h' h'*, and from *h' h'* describe the arcs *l' p'*, *l p*, the centres of the arcs *p' p'* are *q' q'*.

The part between two of the rails, as D D in fig. 163, may be filled up as in fig. 164, in which the line *a b* corresponds to the line *c' c'* in fig. 163, and the parts *c d*, to *c c* in fig. 163. From *e*, where the line *a b* intersects the central line *e g* set off a distance equal to two of the parts in the line *a b*, fig. 163 (fig. 164 is drawn to twice the scale of fig. 163), to the point *f*, and draw parallel to *a b* the line *f g g*. With one fourth of one of the parts in *a b*, fig. 163, as radius, describe circles from the centres *j* and *k*, joining *l* and *m*. Bisect *f l*, *f m*, in the points *h* and *i*, and from these as centres describe the arcs *m f*, *b f*. From *f* set off to the point *q*, a distance equal to half of the distance *e f*, and through *q* draw *r r* parallel to *a b*. From the points *h* and *i*, with radius equal to *h j* or *i k*, describe arcs, joining the circles *j* and *k* with the line *g g*. From *m* and *l* as centres, with distance *m f* as radius, describe arcs *f o*, *f o*, cutting the sides of the rail in the points *p p*, and from the same centres, *l* and *m*, other arcs, as *s t*, *s t*, cutting the line *r r* in the points *t t*. Put in at *t t* the small arc, and join these with the sides of the rail with other arcs described from the centres *l* and *m*. The outside of the rail, as at D', is furnished with the same curve, as shown partly finished at *v v* in fig. 164.

To draw the eaves board in fig. 165, let *a b* be a centre line, and the distance between these points be the height of the board, not including the height of the upper moulding. Divide *a b* into seven equal parts; through the first,

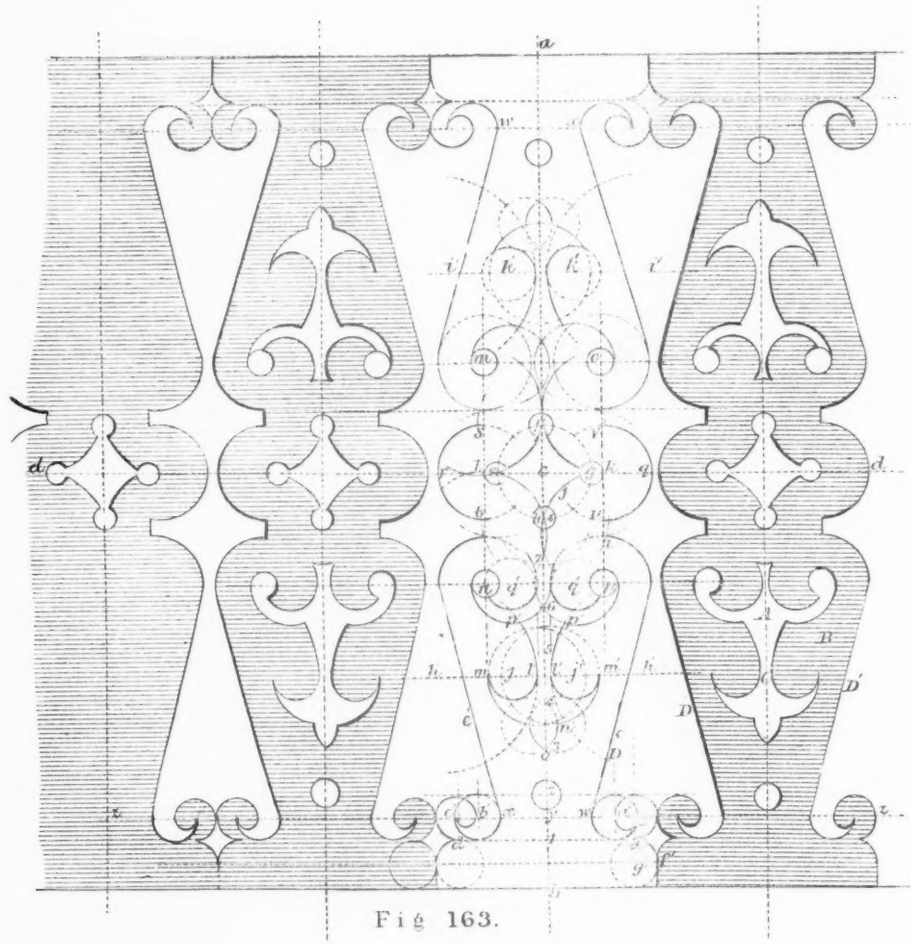


Fig 163.

second, fourth, and sixth points, draw lines at right angles to *a b*, and all parallel to each other. Divide the space between points 5 and 6 into two equal parts in the point *c*. From the point 2 on *a b*, set off a distance equal to one fourth of the diameter of the circle *c*, to the point *d*, and from *d* describe with same radius a small circle *d* 2. Join *d* and *c* by lines, as *e f*, parallel to the central line *a b*, and at a distance from it equal to half the radius of circle *d* 2. With a distance equal to the diameter of the circle *c* 5, set off from the point 2 to *g g*, and join *g g* with the line *h h* passing through the point *a* 1 on the centre line *a b*. Join *h b*, *h b*. From *g* set off to *i*, a distance equal to the radius of the circle *d* 2, and from *i* to *j* a distance equal to the radius of 5 *c* of the upper circle on the line *a b*. From *j*, with this as radius, describe the semi-circle *i k*, and from *k* set off to the point *l*, a distance equal to *g i*, and from *l* to *m*, a distance equal to 2 *g*. Through *m* draw a line *m n* parallel to *a b*, this will be the centre line of the next part of the board, the centre line of the third part being *p o*, this being from the point *m*, a distance equal to 2 *m*. The parts between may be solid, as at A, or with apertures, as at B and C. The part at C is put in thus: with a distance equal to three times the radius of the circle *c* 5, as radius, from the points *q* and *r* as centres, describe arcs as *s t*; and from points *v* and *w* as centres, with radius equal to 5 6, other arcs, as *x x*. From points *v* and *r*, draw a line *v r*, part of which, as *u t*, is left full. In place of terminating the point as at D, fig. 165, this part is described thus:—Bisect *a' y*, *a' z*, in the points *b'* and *c'*, and draw parallel to *a b* or *o p* lines *b' d'*, *c' d'*. Bisect *a' e'* in the point E, and through E draw *f' g'* parallel to *y z*. From points *f' g' d' d'* as centres, with the distance *e'* E as radius, describe arcs, as *i' p*, the inner curves parallel to these being described from the centres *h' h'*, and *d' d'*.

In fig. 166 we give a design for another single eave. Divide the height *a b* into seven equal parts. Divide the space between the

first and second of these in the point *c*, and draw *c d e* at right angles to *a b*. From *c*, with half of the distance 1 2, set off to *d* and *e*, and from these as centre, with a distance equal to half of *c e*, describe the circles *d e;* these are the standards of measurement of the various parts of the design. The arcs *e f*, *d f*, are described from *d* and *e* as centres, with *c* 2, or *c* 1 as radius, these being joined by the arcs *g g*, the radii of these being the distance 1 2 the centres being *i i*, the circle *h* being of the same diameter as *d* or *e*. Through the point 2 draw a line 2 *j*, *l k*, at right angles to *a b*. From the point 2 set off the distance 1 2 to the points *j j*, and through these, parallel to *a b*, draw lines as in the drawing. Make the distance *j l* equal to three of the parts on *a b*, and through *l* draw the line *l m* parallel to *a b*. Through the point 6, draw a line 6 *n* parallel to *j k*. With the distance *c e*, set off from the point *n* to *o o*, and from these as centres, with same distance as radii, describe the small circles *o o;* from *o o* as centres, with distance *o o* as radii, describe arcs cutting as in the point *p*, and from these as *p* complete the ellipse or oval. Make the opening at *q* equal to the radius of the small circle at *o;* through 4, on the line *a b*, draw a line parallel to *j k*, as 4 *s;* from the point *r*, where the line *j r* cuts this, set off a distance equal to one-fourth of the diameter of the circle *d* or *e;* as to the point *t*, join *t q;*

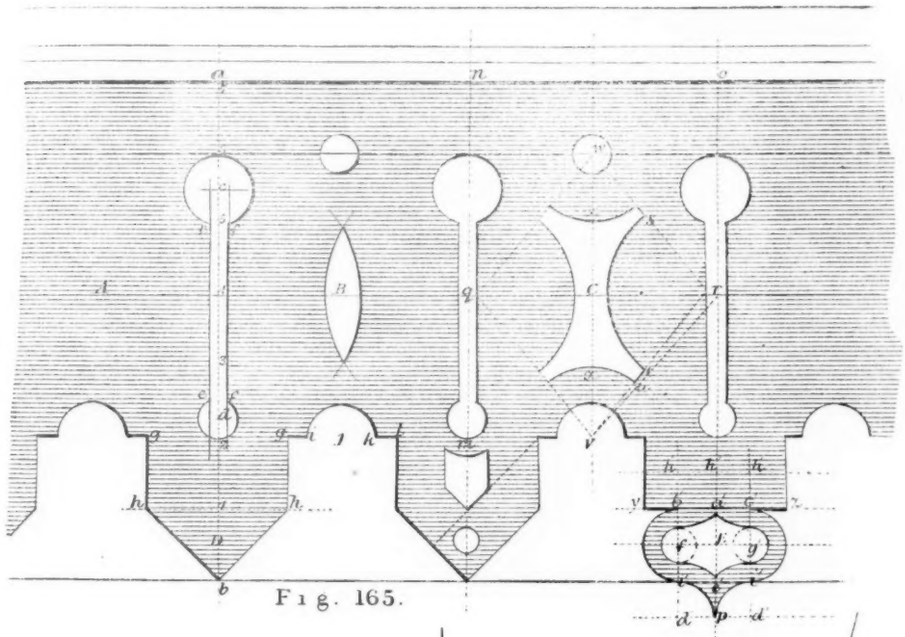


Fig. 165.

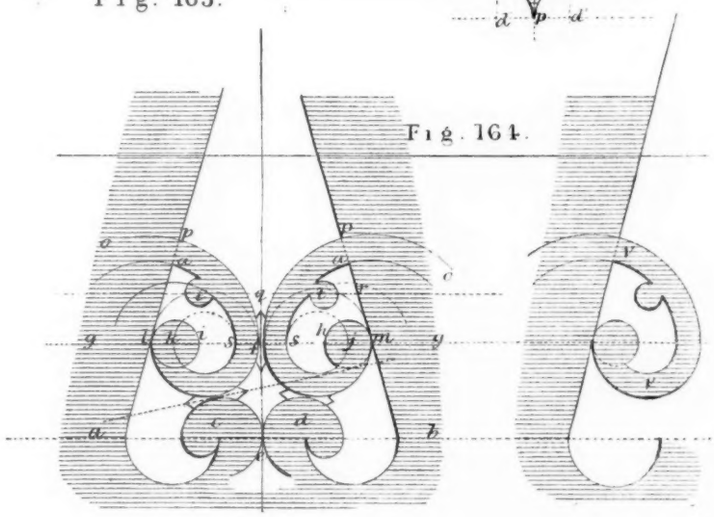


Fig. 164.

bisect this in the point *u*, and through this draw the line to the point *l*. From the points *t*, *u*, and *q*, describe arcs cutting in the points *v* and *w;* from these as centres, with same radius, describe the arcs *t u*, *u q*, cutting in the point *u;* from *u* with distance 1 2, taken from the line *a b*, set off to the point *x* on the line *u l*, and from *x* with the radius of the circle *d* or *e*, set off to *y*, and from this as centre describe the small circle *x y*. With the distance *e f* as radius, join the small circle with the arcs *t u*, *u q*, with the arcs described from the centres *z z*, and finished as at the part A. The part B is put in as shown by the dotted arcs, the centres of which are shown at *a'*, *b'*, and *c'*.

Fig. 167 is a design for a "barge board," or for eaves placed at an angle. Let *a b* be the breadth of one of the pieces. Divide this into three equal parts on the line *a b*. From the first and second of these points draw, at right angles, lines as shown. Bisect the distance 1 2 in the point *c;* and at right angles to *a b* draw the line *c d*. With a distance equal to *c* 2, set off on the line *c d* to the point *e*, and through this draw, parallel to *a b*, the line *h e h*. Divide *c* 2 into two equal parts in the point *g*, and with *g* 2 as radius, from the points *h h* as centres describe the small circles as shown, and from the centres *i i*, with same radius, finish the pendant as at A. With the distance 1 2 from the point *e*, set off to the point *j*, and through this, parallel to *a b*, draw the line *k j k*. With the

distance *c g* from *j*, set off to the point *l*, and draw *l l l* parallel to *k j k*. From the point *j*, with distance *c* 2, set off to the point *m*, and through this draw, parallel to *a b*, the line *m m m*, and make *m n*, *n o*, each equal to *m j* and *j l*; through *o* drawing a line parallel to *a b*, as *s s*. Make *m m* on each side of the central line *c d*, each equal to the distance *l n*. With the distance 1 *g* as radius, set off from *l* to *p*, and from *p* as centre describe the arc *l*, joining with the semi-circle *h*. Through the point *m* draw lines *m l*, *m l*, continuing them through to *r r*. From the points *q q* describe arcs, joining parts of these lines at *r r*, and from the points *s s* as centres, join the arcs described from *q q* with the points *r r*. Join *s m*, *s m*, and from the points *r* draw parallel to *s m* the lines *r d*, *r d*. From the point *h* with the distance *h c*, set off to the point *t*, and through *t*, at right angles, draw the line *t u*. This gives the centre line of the next part of the design.

In fig. 168 we give a design for a circular ornament, the lines of which may be taken as the central lines of parts cut out in wood, or as the lines of the design in wrought-iron rod-work. Let *a b* be the diameter of the interior circle, *c* the centre from which it is described. Draw the diameters *a b*, *d g*, and bisect the quadrants in the points *e* and *f*, and draw the diameter *e h*, *f w*. Divide the radius *c d* into five equal parts. With one of these parts as radius, describe a semi-circle, touching the circle on one side and the diameter at *d g* on the other, the centres of these being as at the points *j* and *k*. Join *j* and *k* with a line parallel to *a b*. Bisect the radius *k l* in the point *m*, and describe the semi-circle *l m* from the point *m*, with *m k* or *m l* as radius. From the point *e* as a centre, with *e n* as radius, describe the arc *n o*. From *k*, parallel to *d c*, draw *k p*; and from *p* as a centre, with *p q* as radius, or two of the parts into which the radius *c d* is divided, describe the arc *q r*. With half of the distance *m l* as radius, describe circles, as from the point *s*, joining the arcs, as *q s*. Repeat all these operations at the corresponding points of the interior circle *d b g a*, as at *o b*. At right angles to *a b* draw the radius *t u*; and from *u* as a centre, with *u o* as radius, describe the arc *o v*, cutting the radius *c e*. With the radius of the small circle as *s*, describe small circles, as at *w*, joining the arcs as *o v*. From the centre *c*, with radius equal to one of the parts as *c d*, describe the circle *x y*; and from the points where this circle cuts all the radial lines drawn from the centre *c* to the circumference *d b g a*, describe arcs, as *z*, touching the arcs as

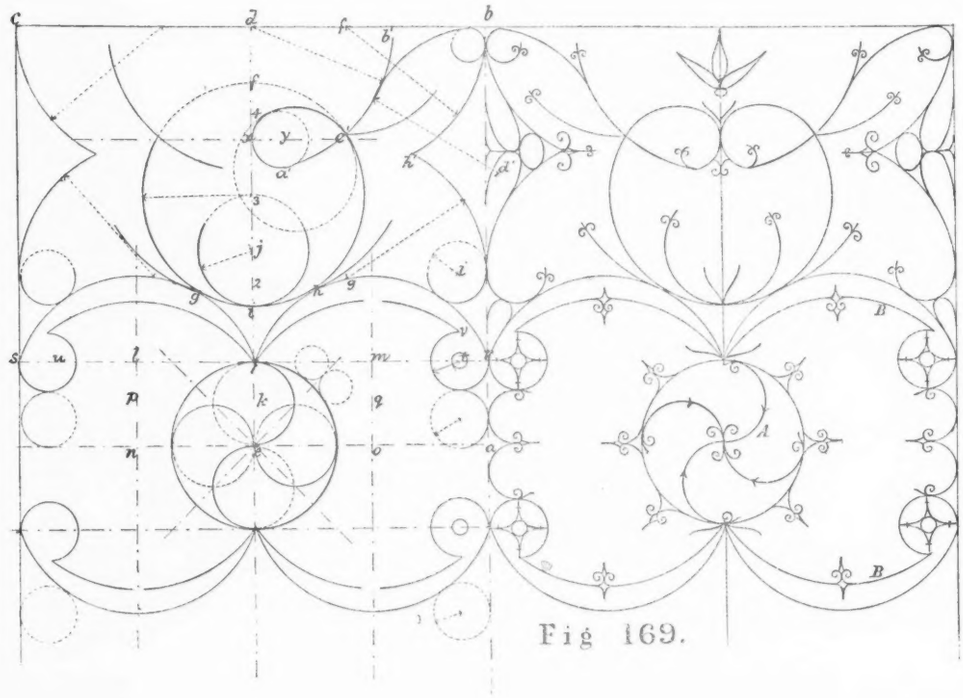


Fig 169.

described from the point *e*. The various arcs of the design will thus be found, and the points finished as at the lower half of the drawing will complete it.

In fig. 169 another design adapted for wrought-iron work, or as giving the central lines of parts to be cut out in woodwork, is given. In the drawing one-half, or the upper part of two of the compartments is given; but the design may be repeated to fill up any given space and length; the lower half is the same as the diagram, only with the parts reversed. Let *a b* be half the height of the completed design, and *b c* the full breadth of one compartment. Divide the distance *b c* into two equal parts in the point *d*, and parallel to *a b*, draw the line *d e*; divide this into five equal parts, as shown. Divide the distance between the points 3 and 4 into three equal parts, and set up one of these parts from the point 4 to *f*. From the point 3 as a centre with the distance 3 *f*, describe the circle *f g h*. Divide the distance *i* 3 into two equal parts in the point *j*, and from this as a centre describe the circle *i* 3. From the point *e*, with *e* 1 as radius, describe the circle 1 *e*, and through the centre *e* draw the radial lines, dividing the circle into six equal parts. Divide the diameter as *e* 1 into two equal parts, as in the point *k*, and from this, with *k e*, describe semi-circles. This will give the curved arms as at A. Through the points *e* and 1 draw, parallel to the line *b c*, the lines *l m*, *n o*; and through these draw lines, parallel to *d e*; on the lines *l n*, *m o* will be found the centres of the arcs of the parts B. With half of one of the parts on the line *d e*, set off from the points *l* and *m* to the points *p* and *q*; from these points as centres, with radii equal to *p g*, *q h*, describe arcs 1 *h r*, 1 *g s*. From *r* and *s*, set off to *t* and *u* distances equal to *f* 4, and from *t* and *u* as centres, with radius *t r*, describe circles as shown. Draw the diameter as *t v* at right angles to the line *l m*, and from the point *q* as a centre, with the distance *q v* as radius, describe the arc *v* 1. From 4 set off 4 *f* to *x x*, and through *x* draw a line parallel to *b c*; from the point *y*, with *y x*, describe the circle *x a'*, and from the point *d* describe an arc *a' b'*. With *d c'* as radius, describe an arc as *c' b*, joining the arc *c' b'* with a small circle described from the point *y*. With the distance *d c'* as radius, from the points *f'* and *g'* describe arcs cutting in the point *h'*; the lower arc runs into a circle described from the point *i*, the radius of which is equal to *t v*. The various parts are finished as at A B.

(41.) **Memoranda on Wrought, or Malleable Iron.**—When cast-iron while in a melted condition is exposed to the action of the atmosphere in a high temperature reverbatory furnace, and stirred or moved about by a process which is technically known as "puddling," the carbon is got rid of, and the mass

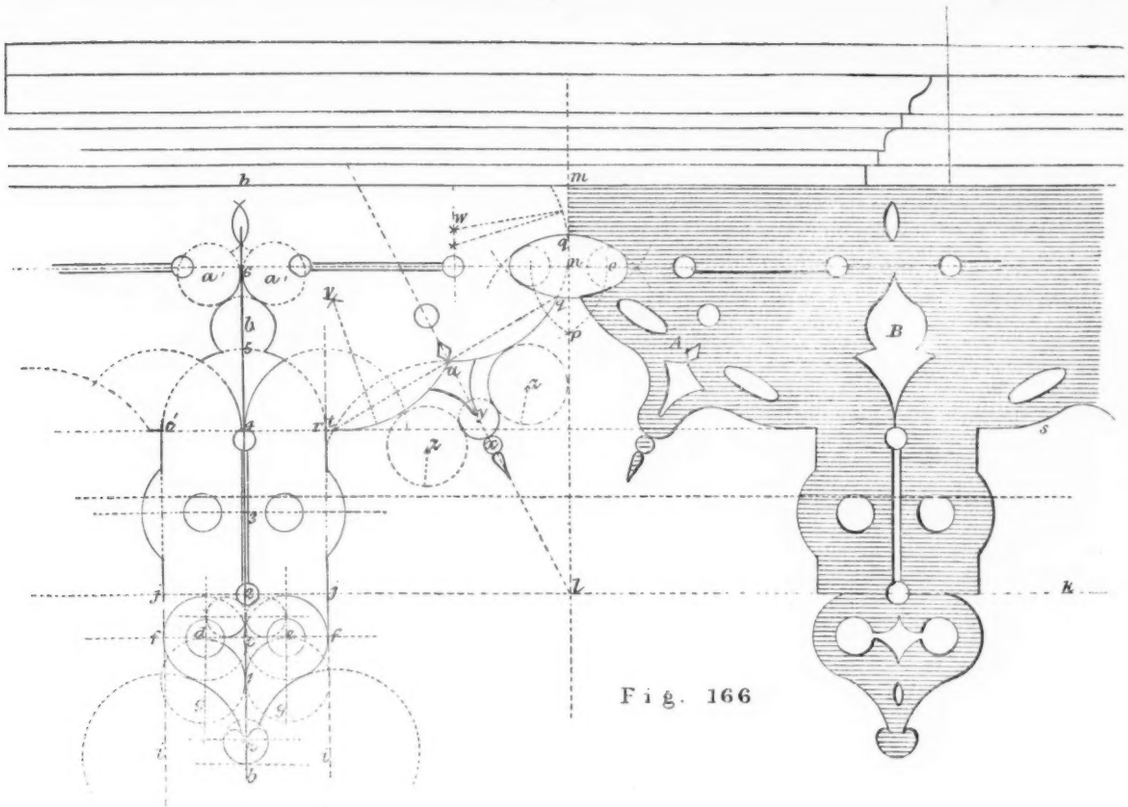


Fig. 166

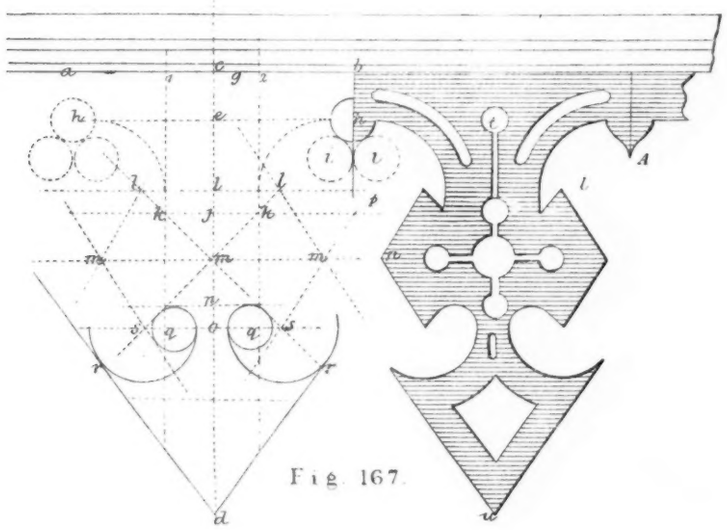


Fig. 167.

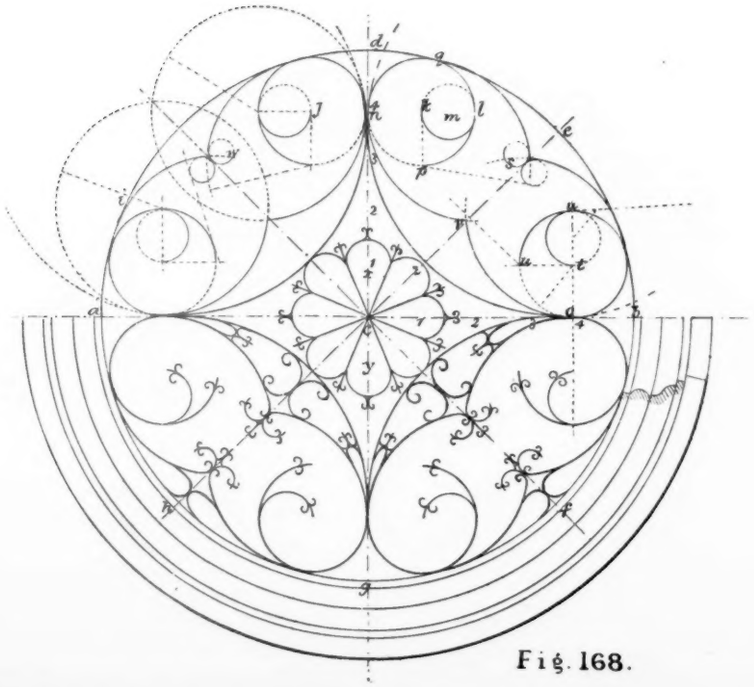


Fig. 168.

is converted into iron capable of being wrought or hammered and welded, and hence called wrought or malleable iron. When the iron in the reverbatory furnace has by the mixing or puddling process become sufficiently viscous or agglutinated, it is withdrawn from the furnace in lumps or balls, which are what is called "shingled"—that is, passed between squeezing rollers, and finally formed into definite shapes by a large hammer. Previous to being puddled, the cast-iron is generally refined in a peculiarly arranged furnace, in which the metal is subjected to a blast of hot air; the iron thus partially decarbonized is then taken to the reverbatory or puddling furnace. In the celebrated process of making wrought iron, invented by Mr. Bessemer, the cast-iron is converted into steel or malleable iron without the intervention of the puddling process, thus saving a vast deal of exhausting and exceedingly expensive labour. Briefly described, the process consists in forcing air into contact with the molten cast-iron, which is placed in a closed vessel.

(*a.*) *Strength of Wrought-Iron to resist Compression.*

Length of Bars.		Side of the Square of Bar in Inches.	Strength or Weight of ultimate Results in lbs.	Power (m.) of the Lateral Dimensions on which the Strength depends.
Ft.	In.			
10	0	·766	1,948	3·56
10	0	1·51	23,025	
10	0	1·00	4,245	4·17
10	0	1·5	23,025	
7	6	1·02	10,236	3·69
7	6	1·53	45,873	
—	—	·5	583	4·08
5	0	1·00	9,873	
2	6	·502	4,216	3·67
—	—	1·00	27,212	
2	6	·502	4,216	3·28
—	—	·76	15,946	
—	—	Mean	—	3·591

"The strength of square pillars of wrought-iron," says Mr. Eaton Hodgkinson, who made the above and also the experiments in paragraphs (*b*) and (*c*) "long enough to become bent without the material being much crushed, is nearly as the 3·59 power of the lateral dimensions, or as $d^{3.59}$, where d is the side of the square, the length being constant. The law of resistance of wrought-iron is therefore not widely different from that arrived at in my experiments with cast-iron pillars, the mean from pillars of this material being 3·6 nearly." The following table shows some of the experiments made by the same authority to ascertain—

(*b.*) *The Comparative Strength of Wrought and Cast-Iron to bear Pressure in the direction of the Length.*

(Note, the length of the bars was 10 feet, and the section one inch square nearly.)

Cast-Iron Bar.—Area of Section, 1·031 x 1·029.		Wrought-Iron Bar.—Area of Section, 1·025 x 1·025	
Weight laid on the end of the Bar in lbs.	Decrease—in parts of an inch—of length by that weight.	Decrease of length of the Bar in parts of an inch.	Weight in lbs. producing that decrease.
—	—	·028	5,098
5,054	·054	·052	9,578
7,316	·078	·073	14,058
—	—	·085	16,298
—	—	·096	18,538
9,578	·102	·107	20,778
—	—	·119	23,018
11,818	·126	·130	25,258
—	—	·142	27,498
14,058	·151	·154	29,738
—	—	—	—
20,778	·173	·174	31,978
—	—	—	—
21,898	·210	·214	34,218
23,018	·247		
27,498	·300		
31,978	·357		
36,458	·423		
40,938	·503		
45,418	·505		
49,898	·694		
—	·749		
54,378	·865		

"From numerous experiments," says Mr. Hodgkinson, "to determine the pressure which wrought-iron would bear as a column, I find that beyond 12 tons per square inch it was of little or no use in practice." The experiments show "that cast-iron was decreased in length about double what wrought-iron was of the same weight; but the wrought-iron sank to any degreee with little more than 12 tons per square inch, whilst cast-iron required twice or perhaps three times the weight to produce the same effect."

(*c.*) *Resistance of Wrought-iron to Tensile Strain.*

(Note, the bars experimented upon were 10 ft. long and 1 sq. in. in section.)

Weight laid on the Bar, W.	Extension of the Bar or value of $12\,e$.	Set of Bar.	The value of $\frac{12\,W}{e}$.
lbs.	Inches.	Inches.	
1,262	·00520		242,665
3,785	·01690	·0005	223,998
6,309	·02772	·0005	227,608
8,833	·03790	·0005	233,061
11,356	·04854	·0005	233,966
13,880	·05950	·0007	233,285
16,404	·06980	·0007	235,016
18,928	·08170	·00130	231,675
21,452	·09310	·00270	230,415
23,975	·10570	·00410	226,824
26,499	·12040	·00680	220,092
29,023	·14500	·0120	200,157
30,284	·19910	·0120	
	·23660	·1082	after bearing the weight 17 hours.
31.546	·24200	·1083	130,357
ditto	·24490	·1111	after five minutes.
35,332	2·04	1·874	17,320

The strength of wrought-iron to resist tension is thus four times that of cast-iron.

(*d.*) *Resistance of Wrought-iron to a Transverse or Cross Strain.*

(Note, the length of the bar was 14′7⅛ in.; the depth in direction of the pressure, 1·585 in.; breadth or thickness of the bar, 5·523 in.; distance between the supports or length of span of the bar, 13 ft. 6 in.)

Weight applied, acting horizontally.	Deflexions after five minutes.	Sets after five minutes.	Ratio of weights to deflexions.	
lbs.	Inches.	Inches.		
28	·051	·0	549	
56	·112	·0	500	
112	·232	·0	483	
168	·344	·001	488	
224	·458	·002	489	
280	·571	·003	490	
336	·684	·003	491	
392	·800	·004	490	
448	·916	·006	489	Mean 498.
504	1·005	·007	501	
560	1·124	·008	498	
616	1·222	·010	504	
672	1·332	·011	504	
728	1·434	·017	508	
784	1·547	·019	507	
840	1·693	·019	496	
896	1·823	·019	492	
952	1·933	·020	493	
1,008	2·044	·021	493	
1,064	2·165	·022	491	

(42.) **Memoranda on Timber.**—*The Felling of Timber.*—When used for building purposes, it is necessary that the trees, at whatever period of the year they may be felled, should not be allowed to stand so long as to exceed their average period of growth. This is important when we consider that timber allowed to be too old before it is cut, is likely to have what is technically known as "star shakes." Star shakes in *old* timber are cracks in the wood, which radiate from the centre to the circumference of the tree, having their greatest width or extent of opening towards the centre of the tree, or that part where the timber is most valuable; whereas in young trees the star shakes, while radiating as above, have their widest opening at or towards the circumference of the tree, or at that point where the least valuable part of the wood is met with. This

point bears, then, upon the value of the timber, but it also appears that the value is influenced by the season of the year at which the timber is felled. The best season would be that immediately preceding the period when the "sap" movements begin in early spring time. Practically, however, the felling season should extend itself from the period when the sap movements or active vegetation ceases in the autumn, to the period before it begins in the spring.

As the sap movements in timber exercise a most important influence upon its value, it will be interesting here to glance briefly at a few points connected with them. The sap of trees, which is composed of oxygen, nitrogen, hydrogen, carbon, and sulphur, and which forms a considerable proportion of the bulk of the green, or fresh wood, is, as may be supposed, a varying quantity, and that according to the season. From the fact that the sap movements are most active in the spring months, it might be supposed that the amount or quantity of sap in trees would be greatest in spring. Accurate experiments show that this is not so, and that the greatest quantity is met with in the months of December and January. It gradually diminishes in the months of October, November, February and March; next in April, May, August and September, the minimum being in the months of July and August. Of course these general statements must be modified by circumstances, such as dry and wet seasons; but the rule, as a whole, stands as we have put it. After being cut down, the sap, as a rule, evaporates gradually; it is only in some cases that the sap is got rid of by its flowing or exuding from the timber, and this flowing out is greatly dependent upon the state in which the timber is after being felled; for if the bark is stripped, the flowing out of the sap from the wood is much quicker than in cases where the bark is allowed to remain on. With bark stripped off, the weight of the sap gradually diminishes; but with the bark on, the evaporation fluctuates, moisture evidently being absorbed from the atmosphere by the bark. The following notes on the "mechanical properties" of various timbers will be useful:—

(*a*). *Proportions of Stiffness in various Woods. English oak being taken as the standard, and put down as* 100.—American oak 114, beech 77, ash 89, elm 78, sycamore 59, larch 79, chestnut 67, cedar 28, Riga fir 98, Memel fir 114, Scotch fir 55, white American spruce 72, yellow pine 95, pitch pine 73, Honduras mahogany 93, Spanish ditto 92, walnut 49, poplar 44, teak 126.

(*b*). *Proportions of Elasticity, or Resiliency. Standard as in* (*a*).—American oak 64, beech 138, ash 160, elm 86, sycamore 111, larch 134, chestnut 118, cedar 106, Riga fir 64, Memel fir 56, Scotch fir 65, white American spruce 102, yellow pine 103, pitch pine 92, Honduras mahogany 99, Spanish ditto 61, poplar 57, walnut 111, teak 94.

(*c*). *Proportions of Transverse Strength. Standard as in* (*a*).—American oak 86, beech 103, ash 119, elm 82, sycamore 81, larch 103, chestnut 89, cedar 62, Riga fir 80, Memel fir 80, Scotch fir 60, white American spruce 86, yellow pine 99, pitch pine 82, Honduras mahogany 96, Spanish mahogany 67, walnut 74, poplar 50, teak 109.

(*d*). *Number of Cubic Feet of Various Timbers, to make one ton in weight.*—Oak (English) 38, do. (American) 53, beech 45, ash 43, elm 53, sycamore 59, larch 72, chestnut 59, cedar 68, Riga fir 48, Memel fir 66, Scotch fir 68, white American spruce 66, yellow pine 80, pitch pine 54, Honduras mahogany 40, Spanish mahogany 50, walnut 42, poplar 34, teak 46.

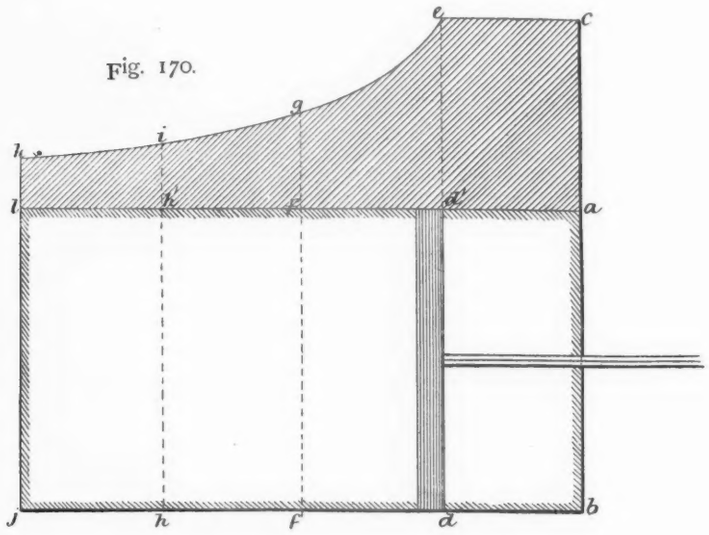
(*e*). *Weight of a Cubic Foot in pounds of different Woods.*—Oak (English) 58, (American) 42, beech 48, ash 52, elm 42, sycamore 38, larch 31, chestnut 38, cedar 33, Riga fir 47, Memel fir 34, Scotch fir 33, white American spruce 34, yellow pine 28, pitch pine 41, Honduras mahogany 40, Spanish mahogany 50, walnut 42, poplar 34, teak 46.

(*f*). *Specific Gravities of various Timbers.*—1. *Oaks*—English 829, Memel 727, Dantzic 720, Italian 796, American white 779, American red 952, African live 1160. 2. *Firs*—American white pine 432, American red do. 576, American yellow do. 508, pitch do. 740, Archangel pine 551, Dantzic 649, Memel 601, Prussian 596, Riga 654, spruce American 772, 503, Mar Forest fir 698, Norway spar 577, deal Christiania 689. 3. *Ash*—English 760, American 626, American Swamp 925, do. black 533. 4. *Beeches*—English 696, American white 711, do. red 775. 5. *Birches*—English 711, American black 670, American yellow 756. 6. *Elms*—English 579, Canada Rock 725. 7. *Cedars*—Lebanon 330, Bermuda 748, American white 354, Guadaloupe 756. 8. *Miscellaneous*—Larch 556, Lignum vitæ 1082, teak 729, iron wood 879, green heart 985, mahogany 608, soft maple 675, acacia 710, hiccory (American) 831, hemlock 911, Canada balsam 548.

(43.) **Memoranda on Steam-Engine Valves and the mode of Setting them.**—In our last note on this subject, No. 32, p. 111, we endeavoured to explain the disadvantages arising from the practice of allowing the steam to gain admission to the cylinder during the whole length of the stroke of the piston, and how these were got rid of by the use of the arrangement of the valve which gave what are termed "lap" and "lead" to it. But in addition to the disadvantages described there and in the preceding note, No. 17, p. 135, another and a very important one arises from the mode of working above recommended. This gives rise to a large waste of steam power, inasmuch as all the advantages arising from the peculiarity which steam as an elastic fluid possesses—namely, its expansibility—are lost. This principle of expansion is of such importance that we shall devote the major portion, if not the whole, of the present "note" to an explanation of its features; as upon these depend much of the methods in use of so setting the valves or so designing them that they will secure to the engine with which they are connected all the advantages to be derived from making use of the principle of expansion. In common with all elastic fluids, as air, steam is capable of being diminished or increased in volume. Thus we can compress air or steam so that it will take up a much less space than it occupies under ordinary or normal circumstances; but as we decrease the space into which it is compressed—that is, decrease its volume—we, in a certain proportion, increase its pressure. And the converse or opposite of this holds equally true; for if we allow a certain volume of steam to expand so as to occupy a greater space than before, as we increase the space we decrease the pressure. The celebrated *savant* Marriotte was the first to investigate the law of expansion, and from his investigation he deduced the law that "the pressure is inversely as the volume." This is now known as "Mariotte's law." Putting this into plain language, we say that if we take a certain volume of steam and compress it so that it will occupy only half of this volume, then we double the elasticity, or in this proportion increase the pressure; if, on the contrary, we allow it to expand into a space double its original volume, we decrease the pressure one-half. Thus, if we suppose the case of a steam cylinder, to which the steam is admitted for one-half of the stroke and then the supply to be cut off, the piston as it gradually proceeds onwards towards the completion of the stroke gradually gives a greater space into which the steam expands, until at its completion, when the space into which the steam has expanded is twice the extent, the pressure is now reduced to one-half of its original amount. Thus, with a gradually increasing volume, we have a gradually decreasing pressure; so that at the end of the stroke we have the maximum amount of expansion with the minimum of pressure obtainable under the particular arrangement.

This is, in fact, what is called "working steam expansively," and the point of the stroke at which the "port" is closed, preventing the access of a further supply of steam to the cylinder, is technically called the "cut-off." This cut-off may be arranged for at any part of the stroke of the piston—one-half, one-third, or one-fourth; in practice it is generally either one or the other of the two last-named proportions; a very usual "cut-off" is one-third. We shall explain in a succeeding paragraph how the "cut-off" is effected by the adjustment of the eccentric and valve in the case of the ordinary slide-valve illustrated in last note, No. 32, p. 309, or by the use of the "link-motion," or by specially arranged "expansion valve gearing;" but meanwhile we proceed to finish our remarks on the principle of expansive working generally. As we have stated, while the steam admitted to a steam cylinder—the supply of which has been cut off at a certain point of the stroke—expands gradually, the volume increasing, the pressure decreasing gradually; it would appear, therefore, that by "expansive working" there would be a loss of power in working. It is so, but there is by it, on the other hand, a saving of steam; and this is so great, that the balance is altogether in favour of the principle. Thus, taking the case of a steam-engine cylinder, the space or volume of steam which fills the whole of it being equal, say, to fifty-nine inches, steam being used at a pressure of fifty pounds, we get, say, a power of two hundred and forty pounds; by "cutting off" the steam at one-fourth of the stroke we now get a power of, say, one hundred and fifty pounds, or thereabouts; but then, as the steam is cut off at one-fourth of the stroke, we have only to expand a volume of steam sufficient to fill one-fourth only of the cylinder, or fifteen cubic inches, thus effecting a saving of forty-four cubic inches; and the cost of this, if expended, would be greater than the loss of the fifty-five pounds of power. It may thus be stated that by working expansively we get from two to two and a-quarter times more work done; or, to put it perhaps more correctly, we effect a proportion of saving of steam equivalent to this proportion of work now stated. We can trace or make graphic what we gain by this mode of working expansively by a diagram, showing what takes place in the conduct of the steam, as we may call it, in the inside of the cylinder of a steam-engine represented by *a l j b*, fig. 170.

Fig. 170.



Let the pressure of the steam be 60 lbs. per square inch on entering the cylinder, draw the line *a i*, and from any scale of equal parts make it equal to 10. Let the steam be cut off at one-fourth of its stroke, as at the point *d*; draw the line *d e*, and make *d e* equal to *b c*, for at this point the pressure on the piston is the same as at *b*, namely, 60 lbs. When the piston reaches the point of half the stroke, the steam will then have expanded to double its bulk, and the pressure will have been reduced one-half, or 30 lbs.; make the line *f g* equal to 30. When the piston reaches the point *h*, or two-thirds of the stroke, the volume is increased one-third, and the pressure to one-third, or 20 lbs.; make *h i* equal to 20; when it reaches the end of its stroke the steam is expanded four times its original bulk, and its pressure is now one-fourth of 60, or 15 lbs; make *l k* equal to 15. If we draw a curve through the points *k i g e*, we should obtain a curve showing the variation of the pressure at these points. Any number of ordinates may be drawn, and the pressure at these points may be obtained by measuring the distance from the scale of equal parts. The mean pressure exerted upon the piston is found by an easy calculation, adding up the mean of all the pressures acting in the spaces, and dividing by the number of spaces.

Pressure in the first $3\frac{1}{2}$ inches on *b d* = 60 lbs.

Mean pressure in *d f* $\frac{60 + 30}{2}$. „ 45 „

Mean pressure in *f h* $\frac{30 + 20}{2}$. „ 25 „

Mean pressure in *h j* $\frac{20 + 15}{2}$. „ $17\frac{1}{2}$ „

$4)\ 147\frac{1}{2}$

36

or nearly 37. Multiplying this by the stroke 4, gives us again $147\frac{1}{2}$ as the measure of the work performed, which is obtained by having $14\frac{3}{4}$ cubic inches of steam admitted to the cylinder in the space *b d*; while by admitting a whole cylinder full, or 59 inches, we have 240 as the measure of (60, the pressure, × by 4, the number of the spaces, = 240) the work obtained. From this illustration, and from what we have already stated, the student will perceive that in calculating or ascertaining the power of a steam-engine, the pressure of the steam in the cylinder is an essential point. At first sight this would apparently be decided with certainty, by knowing the pressure of the steam when it left the boiler; but in practice many things come up which set aside this simple method. The steam generally, we may say in all cases, is led from the boiler to the cylinder by pipes of greater or less length; but this leading of the steam by pipes, even with all precautions taken, such as clothing the outside of the pipes with non-conducting materials, causes a certain loss of pressure by radiation. Then again the steam in passing through the throttle valve, and also through the steam ports, is what is called "wire-drawn." These defects tend to reduce the pressure; and so unequally according to the circumstances of each individual case, that practically it is impossible to say what is the exact pressure of the steam in the cylinder. In estimating the power of steam engines the "effective pressure" is an important element in the calculations; how this is obtained we shall hereafter show. By the use of an ingenious contrivance called the "Indicator," the "conduct" or "behaviour," as some engineers term it, of the steam in the interior of a cylinder, and at various points of the stroke, is so graphically delineated on what is called the "diagram" given by its means, that by the use of this contrivance all defects in the working of the steam-engine valves are very plainly shown, and the increase of the system of working expansively has been greatly promoted.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

Sulphuric Acid Manufacture.—H. A. Smith has examined the causes which determine the mutual action of the gases in the lead chamber and their relative distribution. He finds that the higher the temperature of a mixture of sulphur dioxide and nitrous fumes (prepared by the action of sulphuric acid on sodium nitrate), the more steam is required in proportion to produce a maximum development of oil of vitriol.

The greatest production of sulphuric acid takes place at the bottom of the chamber in proximity to the acid in the "dish" of the chamber, the upper portion of this chamber being merely of use as a reservoir for the gases (?). The most favourable temperature is about 200° F.; long shallow chambers should be used in preference to higher ones, the following dimensions being the best:—150 ft. long, 25-30 ft. wide, and 10-12 ft. high. Sulphuric acid should be used instead of water on the floor of a new chamber to start it. *Phil. Mag.* [4] *xlv.* 23, and *xlvi.* 121.

Synthesis of Formic Acid.—Sir B. Brodie finds that, by electrizing a mixture of hydrogen and carbonic acid, carbon oxide, marsh-gas, and apparently formic acid, are produced. Carbon oxide and hydrogen thus treated yield marsh-gas, whilst

carbon oxide alone furnishes solid substances stated to contain carbon and oxygen only. *Proceedings of the Royal Society, xxi.* 243.

MM. THENARD (*père et fils*) have also observed the fact that a liquid compound is produced by the action of "electric effluvia" on a mixture of carbon oxide and hydrogen, marsh-gas being formed simultaneously; they do not, however, state the precise nature of this liquid compound. When nitrogen and hydrogen are similarly treated, ammonia results, the action being accelerated by the presence of an acid. *Paper read before the Académie des Sciences, April 21st*, 1873.

Caustic Soda.—GLENDENNING and EDGER state that when caustic soda (containing some chlorides and sulphates, and about 5 per cent. of water in excess of the "water of hydration" of the sodium hydrate) is poured in a melted state into drums, the composition of the solidified mass is not at all uniform. The outside layer, of about one inch in thickness, has a composition close upon the average of the whole; the centre has a much lower alkaline strength, owing to the accumulation of water, sulphates, and chlorides; and the part nearly midway between the centre and the walls has a much higher value. Thus, caustic soda containing 66·8 per cent. of available alkali (Na_2O) was poured into a drum eleven inches in radius; after solidification this was sawn across and examined:—

Outside layer one inch thick. Percentage of available alkali,				66·9
Central portion	,,	,,	,,	61·6
Portion five inches from centre	,,	,,	,,	69·7

—*Chemical News, xxvii.* 199.

Helbig's Process for Purifying Caustic Soda.—P. HART writes that the process recently described by Helbig ("Practical Magazine," April, 1873, p. 273) is by no means new. Since 1865 it has been in use in certain works in England, having been invented by himself in that year, without his being aware that the process (blowing air through fused caustic soda) had been previously patented by W. Ralston in 1860. *Cheml. News, xxvii.* 207.

Alkaloids of Cinchona Bark.—CARLES has examined the bark from various species of cinchona, and finds that the majority of the quinine, and probably of the cinchonine also, is contained in the outer cellular layers of the bark. In some instances, however, a considerable amount of cinchonine was found in the liber. Howard has obtained analogous results. *Bull. Soc. Chim. Paris* [2] *xix.* 51.

HESSE gives a detailed history of various alkaloids extracted by himself and others from the bark of trees of the cinchona genus—quinine, cinchonine, conchinine, quinidine, cinchonidine, aricine, paytine, paricine, quinamine, and uncrystallizable bases being specially spoken of. *Ann. Chem. und Pharm. clxvi.* 217.

Non-occurrence of Alkaloids in the Leaves of Cinchona Plants.—J. E. HOWARD has examined about 20 lbs. of the dried leaves of the *cinchona succirubra*. Only minute traces of alkaloids were to be found, and these he considers are probably due to the presence of small fragments of bark from small branches accidentally mingled with the leaves; probably, therefore, the leaves contain no alkaloids at all. *Pharm. J. Trans.* [3] *iii.* 541.

Effect of Manuring Cinchona Plants.—BROUGHTON finds that when the *cinchona succirubra* is manured with ammonium sulphate or guano, an increase in the alkaloids contained is the result; but as this may be due to the exciting action of the manure hastening the change whereby this species loses its alkaloidal character as it grows older, manuring this species is not recommended. *Cinchona officinalis* yields a much larger amount of quinine, and also of total alkaloids, when manured with guano, ammonium sulphate, or farmyard manure, the last being the best. No outward difference is, however, noticeable in the trees through the use of manure. *Pharm. J. Trans.* [3] *iii.* 521.

Preparation of the Hydro-bromides of Quinine, Morphine, Strychnine, &c.—MACDONALD saturates bromine water with sulphuretted hydrogen, so as to produce hydrobromic acid; converts this into barium bromide by means of barium carbonate, and then cautiously adds the sulphate of the alkaloid in question until complete precipitation of the barium as sulphate has taken place, care being taken not to add too much of the sulphate; the filtered liquid is then allowed to crystallize after evaporation. *Chemical. Centralblatt*, 1873, 169.

Reactions of Apomorphine.—QUEHL and KOHLER describe some new reactions of this alkaloid in addition to those mentioned by its discoverers, Drs. Matthiessen and Wright. *Chem. Centralblatt*, 1873, 171.

Sodium Sulphide.—KINGZETT states that when sulphuretted hydrogen is passed over chloride of sodium at a red heat sulphide of sodium is formed to a small extent, hydrochloric acid being simultaneously liberated. *Journal of the Chemical Society, May*, 1873, *p.* 456.

Sulphovinates.—BERTHELOT confirms the statements of Svanberg and Gerhardt (contested by Erlenmeyer and others) that by slowly mixing alcohol and sulphuric acid previously cooled, so that the temperature rises to little above 0°, a sulphovinic acid is produced whose salts are different from those got from the acid produced by allowing the alcohol and acid to become heated. The first class of salts are converted into the second by heat; they are much less stable, and this occurrence is perhaps a reason why some commercial specimens of sulphovinates alter spontaneously on keeping. *Bull. Soc. Chim. Paris*, 1873, *No.* 7.

Valuation of Nitre.—H. JOULE objects to the usual method of valuation of nitre (refraction of nitre), viz., determination of the amount of water, sulphates, chlorides, insoluble matter, &c. &c., and calculation of the difference as nitrate: he proposes to convert the nitrate into chloride by treating with salammoniac in a crucible, and to determine volumetrically the chloride formed, allowing for that previously present determined in the same way; this chloride multiplied by 1·52 gives the amount of nitric anhydride present in the sample. *Comptes Rendus, lxxvi.* 230.

[*Note by Abstractor.*—A most accurate and simple method for the valuation of nitrates free from organic matter is to determine the moisture, and then heat the residue from this determination with a large excess (six or seven times its weight) of pure dry lead sulphate; sulphate of sodium (in the case of nitrate of sodium) is formed, and lead nitrate, which latter wholly splits up into lead oxide and volatile products (nitrogen, oxygen, and oxides of nitrogen). The loss of weight of the crucible gives directly the amount of nitric anhydride present. Pure potassium dichromate may be substituted for lead sulphate, if care be taken not to allow combustible gases and vapours to have access to the heated mass, otherwise a slight reduction of the chromate may take place. With care extremely sharp results may be attained by either method, the presence of a large quantity of sulphate or chloride in no way affecting the accuracy of the result.—C. R. A. WRIGHT.]

Lactophosphates.—ROTHER states that lactic acid readily dissolves many tribasic phosphates, especially those of calcium and iron. To produce a permanent solution of the so-called lactophosphate of calcium the following formula is recommended:—

Precipitated calcium phosphate or calcined bones	about 6 drachms
Lactic acid (concentrated)	1½ troy ounces
Sugar	10½ ,, ,,
Orange-flower water	2 fluid ,,
Hydrochloric acid (sp. gr. 1·16)	1 troy ounce or quant. suf.
Ammonia water	Of each quant.
Water	suf.

The hydrochloric acid is to be mixed with 1 fluid ounce of water, and added to the bone earth previously mixed with 4 ounces of water; when dissolved, the solution is diluted to 12 fluid ounces, and precipitated with ammonia in excess; this washed precipitate is dissolved in the lactic acid, and the solution diluted to 10½ fluid ounces with orange flower water; to 9 ounces of liquor the sugar is added. After solution and straining the rest of the acid liquor is added. *Pharm. J. Trans.* [3] *iii.* 570.

§ 2.—*Metallurgy.*

Mineral Productions of Austria in 1870.—

Gold ore	1,613 tons
Silver	4,627 ,,
Mercury	21,519 ,,
Iron	745,620 ,,
Copper	23,194 ,,
Lead	7,825 ,,
Nickel and Cobalt	44 ,,
Tin	2,069 ,,
Zinc	12,227 ,,
Bismuth	360 ,,
Antimony	55 ,,
Arsenic	427 ,,
Iron pyrites	11,770 ,,
Uranium ore	8 ,,

Mineral Productions of Austria—*continued.*

Chromium	115 tons.
Wolfram	294 „
Manganese	90 „
Graphite	22,271 „
Alum and vitriol ore.	644,472 „
Coal	3,355,913 „
Brown coal and lignite	3,087,662 „
Asphaltum	82 „
Petroleum	331 „

Engineering.

Minerals and Ores from Venezuela.—J. PLANT states that J. M. Spence collected (from the provinces of Barcelona, Bolivar, Carabobo, and Coro, and the neighbourhood of the river Orinoco and Lake Maracaibo) a variety of ores, viz., gold in quartz (those ores from Guayana are very rich, vast regions of auriferous rock, and nuggets, grains, and flakes of gold in clay, occur there; also some in the Isle of Aruba, and Loro Eslado, and Tacasumino); cupriferous and argentiferous galenas (from La Guira, Cumaná, and Coro, not very rich); copper ores, galenas, hematites, specular and micaceous iron ores, siderites, coal, graphite, sulphur, asphaltum, petroleum, pyrites, red silver ore, malachite, native sulphate of copper, &c. &c. Many of them are of high quality. *Paper read before the Manchester Lit. and Phil. Society, January* 27, 1873.

Spectrum of the Bessemer Flame.—W. M. WATTS finds that the majority of the lines which disappear at the end of the "blow" are due to manganese. The temperature of the issuing gases is higher than the melting point of gold (1,300° C.), but lower than that of platinum (2,000°), wires of the first metal being melted when held in the flame, and those of the second being unaffected. *Phil. Mag.* [4] *xlv.* 81.

Solder for Iron and Steel.—SIEBURGER recommends the following mixture for articles of moderate size:—

(1)	Brass melted in a crucible	8 parts.
	Hot zinc gradually added with stirring	1 „

The crucible should be covered and heated to redness for a few minutes; the contents should be granulated in cold water.

(2)	Brass	6 parts.
	Zinc	1 „
	Tin	1 „

mixed and granulated as before.

Fine objects should be soldered either with pure gold, or with gold solder consisting of—

Gold	1 part
Silver	2 „
Copper	3 „

Fine steel wire can also be soldered with tin, but not in a very satisfactory way. *Industrieblätter, ix.* 354.

Welding of Bessemer Steel Waste.—E. WHEELER, of Philadelphia, U.S., has succeeded in solving the above problem. The chief difficulty which has hitherto stood in the way of welding the scraps and waste of Bessemer metal is the circumstance that the steel becomes "burnt," or partially oxidized, on being exposed to the necessary heat. Wheeler proposes to prevent this by surrounding the mass to be heated with a closely fitting wrapper of soft iron. This method permits the Bessemer steel waste to be utilized without necessitating recasting. *Dingler's Polyt. Journ. ccvi.* 241.

Nickelized Specula for Telescopes.—H. L. SMITH suggests the use of iron or bell-metal specula coated with nickel for reflecting telescopes; such a speculum is more reflective than one of speculum metal, and is not affected by sulphuretted hydrogen. A 3 ft. mirror of this description could probably be chiefly made by the aid of a turning-lathe, would not cost the tenth part of the price of a similarly sized one of speculum metal, and in brightness it would be nearly equal to silvered glass, and in polish more enduring. *Paper read before the Manchester Literary and Phil. Soc., April* 1st, 1873.

Calamine from Scharley (Prussian Silesia).—WIESER publishes an analysis of this zinc ore, which is remarkable for containing some phosphoric oxide.

Silica	24·36
Phosphoric oxide	0·51
Ferric „	0·72
Oxide of sodium	0·73
„ potassium	trace
Water	8·46
Oxide of zinc	64·83
	99·61

Verhandlungen der k.-k. Geologischen Reichsanstalt.

Recovery of Tin Waste.—T. F. WELLS treats the scrapings with hydrochloric acid of 22° B. until the acid appears exhausted, when 2 to 3 per cent. (of the acid employed) of nitric acid and 1 to 1½ per cent. of potassic chlorate are added to the bath. The nitric acid forms oxide of tin, which is more easily soluble in dilute hydrochloric acid than metallic tin. The addition of the chlorate prevents the precipitation of hydrate of tin. The dissolving operation is facilitated by placing the scrapings in drums of perforated copper and revolving them in the acid bath which is contained in wooden vats. As soon as the bath is saturated with tin the liquid is drawn off, and the dissolved tin precipitated by zinc.

The solution, containing zinc and a little iron, is used for disinfecting or for conserving wood, or for the manufacture of paint.

To prevent the rusting of the iron, which has thus lost its protecting covering of tin, the drum, containing the scrapings, is put first into a vat with water, and then into a bath of dilute waterglass. [*Dingler's Polytech. Journal, ccvi.* 198.]

Vapour Density of Potassium.—DEWAR and DITTMAR state in a preliminary notice that the specific gravity of potassium vapour with reference to hydrogen is analogous to that of nitrogen, oxygen, &c., and not to that of mercury and zinc, or to that of arsenic and phosphorus; *i.e.* this specific gravity is indicated by the combining number (atomic weight) of the element, and not by half that number, or twice that number. *Proceedings of the Royal Society, xxi.* 203.

§ 3.—*Dyeing, Bleaching, Calico Printing, and allied Subjects.*

Aniline Black.—F. VERSEMANN states that whilst chemically pure aniline does not produce reds or greens, the presence of higher homologues being in these cases indispensable, aniline black can only be made successfully with a pure material, the brilliancy of the colour wholly depending on the purity.

Commercial aniline (aniline oil) is by no means chemically pure, its average composition being:—

	Per cent.	Boiling point.
Pure aniline	60—65	180°—185° C.
Mixture of aniline and toluidine	18—22	185 —192 „
Toluidine	8	192 —198 „
Xylidine, cumidine, and higher homologues	4—6	above 198 „

Hartmann has found the following percentages in commercial aniline:—

Specific Gravity of Sample.	Pure Aniline, B P 180°.	Mixture of Aniline and Toluidine, BP 180°—185°.	Mixture of Aniline and Toluidine, BP 185°—192°.	Toluidine, B P 192°—198°.	Higher Homologues, B B 198—215.
2° Beaumé	6 per cent.	62 at 2·75° B.	20 at 1·6° B.	10 at 0·6 B.	2
3 „	12 „	50 „ 3·4 „	24 „ 2·1 „	6 „ 1·0 „	8 at 0·5 B.
2·25 „	8 „	54 „ 3· „	22 „ 1· „	10 „ 0·9 „	6 „ 0·5 „

By practically testing a large number of samples of aniline and other substances from various sources by printing black with the following mixture, the conclusion is deduced that whilst products boiling at 180° to 185° give a brilliant black, Coupier's toluidine (sp. gr. 0·880 B.) gives only brown chestnut. Thus whilst other samples of products boiling above 192° give uneven shades of no distinct colour, pseudo-toluidine and products boiling at 185° to 192° give a black with a blueish shade. The mixture experimented with had this composition:—

Thickening	9 gallons.
Potassium chlorate	5 lbs.
Ammonium chloride	5 „
Copper sulphate	5 „
Aniline oil	6½ „
Tartaric acid	7½ „

The true value of any sample of commercial aniline can be found by fractional distillation, the quantity boiling at 180° to 185° being taken to represent the relative value, *i.e.* the amount of pure aniline present (this is, of course, only in reference to the use of aniline for black).

With the above mixture, 4 lbs. of Coupier's pure aniline is the least quantity that will yield a good black; comparative experiments with different quantities of aniline enable a judgment to be made as to the value of a given sample, the more aniline being required to give a good black with this mixture the less being the value of the sample examined. Strong sulphuric acid, diluted with three times its weight of water, when added to

good aniline forms a thick paste of aniline sulphate; if tarry impurities or nitrobenzol be present, these float up to the top when the mass is dissolved in water. The determination of the specific gravity also serves as a quick test; aniline of 2° to 3° Beaumé (3° to 4° Twaddell) gives a good black if not fraudulently adulterated; if heavier, nitrobenzol is probably present; if lighter, toluidine is probably present in such quantities as to interfere with the development of the black, and to give much trouble in printing.

If aniline hydrochloride (aniline salt) be used, the following recipe answers well for printing black:—

	Potassium chlorate	3 lbs.
	Aniline salt	7½ „
	Copper sulphate	3 „
or	Copper chloride solution, at 57° B. (88° T.)	6 „
	Water	10 gals.

Thickening as required.

The total consumption of aniline oil during the last few years amounted to—

1867	1,500,000 lbs.
1868	2,000,000 „
1869	3,500,000 „

Out of this, Germany employed 2,000,000 in 1869; Switzerland took the most of the remainder, England employing a smaller portion, and France least of all. On the other hand, the production of aniline in Germany was scarcely 1,000,000 lbs. France manufactures about 2,500,000 lbs. England supplies the largest quantity of benzol, most of this, however, being exported, and manufactured aniline being largely imported. In 1869, 90,000 lbs. of English and French iodine were used for making iodine green, of which 65,000 lbs. were consumed in Germany.

To produce 3,500,000 lbs., or 1,600 tons of aniline, more than 2,500,000 tons of coal are required, which would furnish at least 25,000,000,000 cubic feet of gas, the quantity being calculated from the following data:—

100 parts of coal		yield .	.	4·5 parts of tar.	
100 „	tar	„ .	.	1·5 „	benzol.
100 „	benzol	„ .	.	130 „	nitrobenzol.
100 „	nitrobenzol	„ .	.	70 „	aniline.

Whence 1 ton of aniline requires for its production 1,600 tons of coal. *American Chemist*, 1873, 299, *from a pamphlet privately printed by Rumpff and Lütz, importers of aniline oils, &c.*

Ethyl and Methyl Aniline.—SPILLER states that the body known as "Hoffmann's gum" yields either methyl aniline or ethyl aniline on destructive distillation, according as the gum is a bye-product of the action of methyl or ethyl iodide on rosaniline in the manufacture of Hoffmann's violet. The production of this gum is greater when larger proportions of iodide are used so as to produce bluer shades. The methyl and ethyl anilines thus produced appear to be identical with the ordinary bodies of these names, and, like them, can be used in the manufacture of colours. *Proceedings of the Royal Society, xxi.* 204.

Wool-Dyeing with Indigo.—KUGLER states that the chief "sickness" to which the indigo vat is liable is the blackening of the vat, or "sharpening," due to the presence of an excess of lime. The liquor in this case is of a dark blackish-green colour. There is no film on the surface, but, on being stirred, a white or grey scum appears, a pungent odour being simultaneously emitted; whereas in the natural state the liquor is of a waxy yellow tint, and has a dense blue film on the surface. If the vat be only slightly affected, the addition of some bran and madder is sufficient to cure it, a few hours' rest being allowed: if this treatment be not sufficient, the vat should be heated and agitated, and allowed to stand a couple of hours; after this treatment the addition of a little lime may be necessary. The sickness is due to the setting free of the ammonia (formed by the decomposition from the butyric fermentation set up) by the excess of lime; bran causes a lactic fermentation, the lactic acid neutralizing the alkali. Mineral acids may be used, but there is a great danger of precipitating the indigo. *Reimann's Färberzeitung, Nos.* 16, 17, *and* 18.

Economy of Indigo in Printing Blues.—The fabric to be coloured yellow, green, or orange is printed with yellow-green paste, and then placed in a vat containing a decoction of catechu, and finally in the indigo vat. When dyed to the desired extent, it is treated with potassium chromate, whereby the catechu tint is brought forward, and the indigo-blue ground developed. For light blue and white the fabric printed with the protecting paste is stretched on a frame and immersed in a vat containing 12 lbs. logwood extract to 600 litres of water; it is then placed in a bath of 6 lbs. copper sulphate to 300 litres of water, and, after a time, treated again in the logwood bath; 6 lbs. of alum are added to the copper bath, and the goods again immersed in it. Finally the piece is cleansed in a bath of 12 lbs. alum and 300 litres of water. If an indigo-blue tint is required, the goods must be placed in the indigo vat before treating with logwood and copper. *Dingler's Polytech. Journal, ccvi.* 334.

New Method for the Preparation of Alizarin from Paranaphthalene, Anthracene, or their Homologues.—C. GIRARD employs a product which distils between 290° and 360° C., and, after having purified it by distillation and pressure, the substance which passes over between 300° and 335° is collected. This mixture is treated with potassium chlorate and hydrochloric acid, so that it is converted into tetrachlorinated products. These products are oxidized either by nitric acid in the water-bath, or by a metallic oxide (red or brown oxides of lead) and sulphuric or acetic acids. In the first case, a mixture of dichloranthraquinone and chloride of chloroxyanthranyl are obtained. These substances are treated in presence of a metallic oxide (zinc or cupric oxide, or litharge) with an alcoholic solution of sodium acetate. The metallic oxide removes the last atom of chlorine from the sodium chloroxyanthranilate, and converts it, like the dichloranthraquinone, into alizarin.

The purification is effected by means of benzol, petroleum, etc., which dissolve out the foreign matters, and by successive precipitations from alkaline solutions by mineral acids. The impurities may also be separated by means of a little alum, when it is necessary to work with neutral potash or soda salts. *Bull. Soc. Ind. de Mulh. xlii.* 54.

Application of Artificial Alizarin in Calico-Printing.—The "Muster-Zeitung" states that the artificial dye is rapidly displacing madder root. Several new factories have been erected in Germany for the production of artificial alizarin, and many great dyeing establishments have already given up entirely the use of madder-root. *Polyt. Centr.* 1872, 1298.

Anthrapurpurin.—PERKIN finds that artificial alizarin contains a dyeing material, the composition of which is indicated by the formula $C_{14}H_8O_5$; alizarin being $C_{14}H_8O_4$; this substance is very similar to alizarin in tinctorial power, having about the same affinity for mordants, and producing red with alumina, and purple and black with iron mordants. The red shades produced by the new dye are, however, more pure in tint and less blue than those from alizarin, while the purples are bluer and the blacks more intense; the fastness of the colours against soap and light is equal to that of the alizarin colours. When used to dye Turkey red the new material produces very brilliant colours of a scarlet shade and of remarkable permanence. The separation of anthrapurpurin from alizarin is effected by converting the mixed dyes into alumina lakes and treatment with carbonate of soda solution; anthrapurpurin is dissolved out, whilst alizarin lake is untouched. The same result is arrived at if the mixture be dissolved in a dilute solution of carbonate of soda, and the liquor agitated with freshly precipitated alumina; the alizarin is thus precipitated as a lake, whilst the anthrapurpurin remains in solution. Crude artificial alizarin also contains anthraflavic acid and a substance (under investigation) which dyes alumina mordant of an orange colour. *Journal of the Chemical Society* [2] *xi.* 425. *May*, 1873.

Separation of Woollen and Cotton Fibres.—Rags containing two sorts of fibres are technically termed "shallies;" from these the woollen threads can be separated by treatment with dilute solution of hydrochloric acid, whereby the cotton is converted into sugar, &c., the wool being unchanged. Thousands of tons of shoddy are annually made by tearing up in "devils" the woollen threads thus separated. If boiled with alkalies, mixed fabrics of this description are disintegrated, the woollen fibres being in this case attacked, and the cotton remaining unchanged. F. O. Ward has devised a process by which animal fabrics (wool, silk, leather, &c.) may be thus obtained in a saleable form fit for manure, whilst vegetable fibres (cotton, flax, hemp, &c.) are retained unchanged. This process consists in treating the mixed fabrics with steam, whereby the animal matters are reduced to a varnish-like coagulum, becoming a brittle, friable mass when dry; the mass is beaten and sifted when the pulverized nitrogenous animal matter passes through the sieve, the cotton, &c., remaining on the sieve, and being sold as paper material of medium quality, equal to the variety technically known as "colours." *Vide* "Chemical Jury Report of the International Exhibition of 1862." *Chemical News, xxvii.* 209.

Rouge de Tournai.—This dyestuff is met with as a paste; cotton is dyed of a deep red colour with it by first communicating a strong "Orleans" ground tint, then washing and impregnating with aluminium acetate liquor (the goods remaining six

hours in this acetate bath), and finally dyeing in a warm bath of "Rouge de Tournai," the tint being proportionate to the quantity of dyestuff used in the bath. *Dingler's Polytech. Journal, ccvi.* 334.

Black for Woollen and Cotton-wool thick Goods.—The pieces to be dyed are mordanted for an hour and a half in a bath containing 2½ kilogrammes potassium dichromate, 1 kil. copper sulphate, and 1 kil. sulphuric acid to every three pieces. The next day the goods are dyed with 50 kils. campeachy, 5 kils. yellow wood, and 1 litre ammonia liquor; the whole is boiled for an hour, left all night, and washed with urine. For a second operation, 2 kils. dichromate, ¾ kil. copper sulphate, and ½ kil. sulphuric acid are added to the first bath; a less amount of campeachy and yellow wood, with ½ litre of ammonia, being added to the second vat, so as to bring it up to strength. *Moniteur de la Teinture*, 1873, *Feb. 5th.*

Aurin.—DALE and SCHORLEMMER have further examined the product of the action of oxalic and sulphuric acids on phenol, and find that the tinctorial constituent of the dye-stuff formed (sold under the names of *aurin, yellow corallin*, and *rosolic acid*) is a substance expressed by the formula $C_{20}H_{14}O_3$, not identical with a body termed corallin, recently obtained by Fresenius from the same materials but at a higher temperature. When treated with aqueous ammonia at 140 to 150°, aurin forms a new colouring matter, sold as *pæonin* or *red coralline*, which dyes wool and silk a redder shade than aurin; and when treated with aniline a blue dye-stuff is formed known as *azurin*, or *azulin*. *Journal of the Chemical Society*, 1873, *May, p.* 434.

PRUDHOMME states that the process of making rosolic acid consists in heating to 140° to 150° C. for five or six hours a mixture of 1 part oxalic acid, 1½ parts phenol, and 2 of sulphuric acid. The formation of a conjugated sulpho-acid of phenol does not appear to be a necessary stage in the transformation, as any other dehydrating agent besides sulphuric acid (*e. g.* boric, arsenious, or arsenic acids, &c.) also gives rise to rosolic acid. Again, anhydrous oxalic acid (sublimed) when heated with phenol forms the colouring matter, but ordinary crystallized oxalic acid (containing water of crystallization) does not produce it. The author concludes from his experiments that the production of rosolic acid is solely due to the direct action of nascent carbon oxide on phenol. *Bulletin Soc. Chim. Paris, xix.* 359.

Elsner's Zinc Green.—Zinc oxide 5 lbs., cobalt sulphate 1 lb. Mix with sufficient water to form a paste, and heat to redness; a deep green pigment results. With zinc oxide 10 parts, and cobalt sulphate 1 part, a grass-green powder is obtained, and with 20 parts zinc oxide a light grass-green pigment is produced capable of being used instead of arsenic green. This green is permanent in contact with lime (as in mortar, &c.), and has thus an advantage over green made from mixtures of chrome yellow and Prussian blue.

§ 4.—*Food and Sanitary Matters.*

Filtration of Water.—The filtering beds of the various London water supply companies are stated to have the following compositions and thicknesses:—

	New River.	East London.	Southwark.	West Middlesex.	Chelsea.
Fine sand	2′	3′ 5″	3′4′	2′ 9″	2′75′
Coarse sand					
Shell sand	...	...	...	...	0′15′
Fine gravel	3′	...	1′	1′ 9″	0′15
Medium gravel		...	0′75	...	3′
Coarse gravel		...	0′75	...	
Very coarse gravel		...	1′	...	
Altogether	5′	3′ 5″	6′5 to 7′5	4′ 6″	8

	Lambeth.	Grand Junction.	Kent.	Hampstead.	Plumstead and Woolwich.
Fine and coarse sand	6′	Same as the South-wark company.	2′	1′25′	No filtering beds at all.
Shell sand			0′5	...	
Fine and medium gravel			2′	0′5	
Coarse gravel				0′5	
Very coarse gravel				1′0′	
Total	6′	6′5 to 7′5	4′5′	3′25	

Journal für Gasbeleuchtung u. Wasserversorgung, No. 7.

Mineral Waters of Bad Ems.—R. FRESENIUS examined the nature of these waters in 1851, and has again made analyses of their constituents, with the following results in grammes per litre:—

	Name of Spring.			
	Kessel-brünnen.	Krauchen.	Fürsten-brünnen.	New Spring.
Specific gravity	1·003028 at 17°	1·00308 at 16·9°	1·00323 at 16·9°	1·00300 at 17°
Temperature	46·64°	35·89°	39·42°	50·04°
Sodium bicarbonate	1·9997	1·9790	2·0366	2·0527
Lithium	0·0057	0·0040	0·0044	0·0055
Ammonium	0·0071	0·0024	0·0025	0·0082
Sodium sulphate	0·0156	0·0335	0·0171	0·0415
,, chloride	1·0313	0·9831	1·0110	0·9271
,, bromide	0·0005	0·0003	0·0003	0·0005
,, iodide	0·0000035	0·000022	0·000022	0·000004
,, phosphate	0·0005	0·0015	0·0015	0·0004
Potassium sulphate	0·0437	0·0368	0·0485	0·0442
Calcium bicarbonate	0·2196	0·2162	0·2170	0·2204
Strontium ,,	0·0018	0·0023	0·0025	0·0015
Barium ,,	0·0012	0·0010	0·0010	0·0010
Magnesium ,,	0·1825	0·2070	0·2056	0·2103
Ferrous ,,	0·0033	0·0020	0·0019	0·0040
Manganous ,,	0·0003	0·0002	0·0002	0·0003
Aluminum phosphate	0·0002	0·0001	0·0001	0·0002
Silica	0·0485	0·0497	0·0500	0·0475
Free carbonic acid	0·9302	1·040	1·0295	0·7463

Journal Prakt. Chem. [2] *vi.* 53.

Water from Springs of Partenkirchen.—WITTSTEIN has examined the waters from the springs situated about 53 miles from Munich, with the following results in parts per 1000:—

Specific gravity	1·000674 at 12° R.
Temperature	5·25° R. (air being — 1·25° R.)
Potassium sulphate	0·0437
Sodium sulphate	0·0547
,, thiosulphate	0·0005
,, chloride	0·0247
,, nitrate	traces
,, phosphate	0·0021
,, bicarbonate	0·5166
,, bromide	traces
,, borate	traces
Lithium bicarbonate	traces
Ammonium ,,	0·0097
Barium ,,	traces
Calcium ,,	0·1171
Magnesium ,,	0·0278
Ferrous ,,	0·0010
Silica (free)	0·0120
Carbonic acid	0·0100
Sulphuretted hydrogen (free)	0·0179
Organic matter	0·0484

Chem. Centr. 1872, 521.

Softening of Water by boiling with Lime.—J. STINGL points out that an excess of lime must be avoided. To determine the amount of lime necessary to be added, he treats lime-water with a decinormal nitric acid solution coloured with litmus until neutral. The amount of lime in one cub. cent. of the solution is thus ascertained. This standard lime-water is then passed, from a burette, into 100 cub. cent. of the water under examination, until a flocculent precipitate begins to form; at this point the water should show an alkaline reaction with turmeric paper (by Pettenkofer's method). From the number of cub. cent. used the amount of lime is calculated, and this may be reduced to dry lime per cubic foot of water.

The following is an example of the practical application of the above method:—

10·000 parts of water were found by analysis to contain in 10·000 parts:—

Sodium chloride	1·1459
Sodium sulphate	0·0375
Gypsum	0·8971
Lime carbonate	2·7510
Magnesia carbonate	1·6562
Silica	0·1090
Iron oxide and alumina	0·0145
Nitrates	traces.
Organic matter	1·6420
Total solid matter	8·2532

Assuming that the lime and magnesia carbonates are held in solution as bicarbonates, 1 equivalent of lime carbonate, corresponding to 50 parts by weight, demands 1 equivalent of lime (CaO), corresponding to 28 parts by weight, in order to fix

that equivalent of carbonic acid which keeps the calcic carbonate in solution. Hence the proportion:

$$50 : 28 = 2{\cdot}7510 : x$$
$$x = 2{\cdot}7510 \times 0{\cdot}56 = 1{\cdot}5405 \text{ (CaO)}.$$

The amount of lime required to precipitate the dissolved carbonate is therefore found by multiplying the analytical figures expressing the quantity of lime carbonate by 0·56.

By means of a second proportion, we obtain the coefficient $\frac{2}{3}$, by which the quantity of magnesia carbonate found in analysis (in the present case 1·6562) has to be multiplied in order to know the amount of lime required to throw down the magnesia. *Dingler's Polyt. Journ. ccvi.* 304.

Estimation of Hardness of Spring Water.—MOHR refers to a recent critique by Wagner on Clark's well-known soap test, stating that the method suggested instead by Wagner (addition of cochineal tincture and of standard acid until the purple tint disappears) was published long ago by himself. This method indicates carbonates of magnesia and soda, as well as carbonate of lime, and does not indicate chloride, sulphate, or nitrate of lime. The total lime present is most easily determined (in the absence of magnesia) by precipitation with oxalate of ammonia, and determination of the precipitate by a standard solution of permanganate of potash. *N. Repert. Pharm. xxii.* 164.

Estimation of Nitric Acid in Well Water by means of Indigo.—F. FISCHER reviews the results obtained by various other chemists in connection with this process, and states from his own experience that whilst this method gives good results with pure solutions of nitrates, it always gives too small a result in presence of organic matter; moreover, the quantity of sulphuric acid added influences the result, higher values being obtained with larger quantities of acid; pure solution of indigo carmine must be employed, and, of course, pure sulphuric acid. *Journal Prakt. Chem.* [2] *vii.* 57.

[*Note by Abstractor.*—This method seems to be greatly inferior in accuracy to the one usually employed, viz., evaporation of the water to a small bulk, transference to a graduated tube filled with mercury, addition of sulphuric acid, and reading off the bulk of nitric oxide formed after agitation for as long as the quantity of gas formed shows any increase. C. R. A. WRIGHT.]

Nitric Acid in Spring Water.—WAGNER calculates that the amount of nitrates contained in the water from the pipes of Munich would represent 679,000 kilogrammes (679 tons nearly) of saltpetre, or 18,106 cwt. of gunpowder; whilst that from the wells of the city would represent 4,071,200 kilogrammes of saltpetre (4,071 tons nearly) or 108,568 cwt. of gunpowder. *Journal für Gasbeleuchtung und Wasserversorgung, No.* 8.

Clarification of Beer.—BRESCIUS recommends that about 140 grammes of tannin dissolved in 750 ccs. of water should be added to each 1,000 litres of beer, and well mixed with it; after three or four days, 1 litre of fish-glue or two of gelatine (1 kilogramme of glue to 100 litres) should be added. Usually a week is necessary for complete clarification, but the time is subject to great variation. *Polytechnisches Notizblatt, xxvii.* 342.

Extract of Hops.—GRIESSMAYER obtains (by a process the details of which are kept secret) an extract of hops which is much more convenient for use than the hops themselves, and furnishes an equally good beer; the extract is used at Augsburg on a very large scale. *Polytech. Notizblatt, xxviii.* 5.

Valuation of Milk.—J. MUTER employs the following process: A small quantity (5 drops) is dropped on to a weighed quantity of oxide of copper, which is then weighed; the whole is then dried at 105° and weighed again; the residue is then burnt in vacuo with more oxide of copper, as in Frankland's method of water analysis, the gases being collected by the aid of a Sprengel pump. Thus the water, the nitrogenous constituents, and by difference the sugar, fat, &c., can be calculated from the results of one operation. *Zeitschrift, Annal. d. Chemie, xi.* 350.

GARSIDE finds that very different percentages of cream may be obtained from the same milk according as the temperature at which the milk is kept varies. Those samples which contained 14, 12, and 14 per cent. of cream at 43° F. only give $8\frac{1}{2}$, 8, and 12 respectively at 60° F. *Pharm. J. Trans.* [3] *iii.* 582.

Salting Meat.—NESSLER considers the questions, what are the best proportions of salt, sugar, and saltpetre? and is it better to treat the meat with a dry mixture of the above substances, or to dissolve the salts and the sugar in water and to apply this solution? As to the first point, he recommends a mixture of 6 pounds of common salt, 3 ounces of nitre, and 1 pound of sugar to every cwt. of meat; these figures correspond very closely to the proportions employed for salting meat in England. As to the second question, he is in favour of using a solution instead of the dry mixture, because this latter extracts from the meat not only water, but also some of the most nutritive constituents. On the other hand, it must not be overlooked that salting by means of brine requires special care in order to ensure thorough contact of all the parts of the meat with the salt, and also a longer time for subsequent drying. [*Dingler's Polyt. Journ. ccv.* 494.]

Preparation of Albumin from Blood and from Eggs.—E. CAMPE recommends, on the outset, that the dishes and sieves for the separation of the serum should be in close proximity to the slaughter-houses, since the retarding of that separation is almost sure to be followed by more or less colouring of the serum, which, of course, leads to a dark-coloured albumin.

The blood clot is cut into small lumps, placed on the sieves, and left there for forty to forty-eight hours. The first portions of the serum which pass through are always red, but after the lapse of about an hour the percolating liquid shows a clear and yellow colour, the tinge varying, according to the variety of the cattle, from deep gold to that of pale hock. After forty-eight hours the clear serum is drawn off, care having been taken that the lowest layer containing the red blood corpuscles is kept back. About 25 to 30 per cent. of serum is thus obtained from ox blood, and this raw material can now be manufactured into either the so-called "natural albumin" or the "patent albumin."

The first-named substance is obtained by simply drying (in chambers heated to about 50°55° C.) the serum previously purified by means of oil of turpentine. The oil—a quarter of a pound to every cwt. of serum—is whipped into the fluid albumin and the liquor allowed to stand for twenty-four to thirty-six hours, when the oil is found floating on the surface, together with various impurities.

The "patent albumin" is prepared by mixing the serum previously to the addition of the oil of turpentine with a dilute aqueous solution of acetic acid to which a little sulphuric acid is added. The best proportions are:—12½ ounces of acetic acid and about 1 ounce of sulphuric acid dissolved in 6 pounds of water to 1 cwt. of serum. After stirring the liquid for a short time, the oil of turpentine is added. The whole is then left to settle for twenty-four to thirty-six hours, drawn off, neutralized with ammonia, and dried.

Both these albuminoid preparations are called "primary" products, as distinguished from "secondary" and "tertiary" products which are obtained from the residues left in the dishes after the drawing off of the pure serum and from the clot on the sieves. The albumin from the last named source is, of course, of very inferior quality, but is largely used in sugar refining.

With regard to the manufacture of albumin from eggs, the author recommends careful separation of the white from the yolk. Since that, however, cannot be perfectly accomplished, the white of eggs is refined by whipping up with oil of turpentine and a trace of acetic acid. The further treatment is the same as that of albumin from blood.

From a pecuniary point of view this latter process does not appear to be advantageous, at least not in Moravia, Silesia, and Saxony. An important condition for the profitable production of albumin from eggs is the possibility of easily disposing of the yolk. Since this cannot always be done in the neighbourhood of albumin factories, and as transporting the material to some distance is apt to produce decomposition, it is necessary to add to it some antiseptic substance. Campe finds a solution of soda arsenate in glycerine, to which some salt is added, best suited for the purpose. Carbolic acid, soda, hyposulphite, &c., have been more or less successfully tried, but found objectionable on the part of tanners and glovers, who are the chief consumers of yolk of egg. The first imparts to the leather its penetrating smell, the latter produce stains. *Dingler's Polyt. Journ. ccvi.* 56.

Influence of Manure on Plants.—MASTERS and GILBERT have grown different kinds of meadow plants separately in wooden boxes, both without manure and with five kinds of manure, consisting of a cinereal mixture containing potash, phosphates, &c., ammonium salts, cinereals and ammonia, sodium nitrate, and cinereals with sodium nitrate. With clovers (*trifolium pratense* and *repens*, and *Lotus corniculatus*) nitrogenous manure with cinereals gave the best results, cinereals alone having little or no effect. With grasses also, cinereals alone had little effect; *Dactylis glomerata* appeared to be benefited by ammonia, *Anthoxanthum odoratum* by nitrates, the best crop in each of six instances being obtained by a mixture of cinereals and nitrogenous matter. *Carum carui* was apparently benefited

by cinereals alone; both this plant and *plantago lanceolata* gave the best result with the mixture of nitrates and cinereals, whilst *Achillea millefolium* was most benefited by cinereals and ammonia.

In no case did the habit of growth of the plant appear altered by the influence of the manure. The development of the roots indicated that those plants which dispossess others under liberal manuring are those whose habit of growth gives them the widest hold of the soil. *Journal of Horticultural Society*, 1872, 19; *and* 1873, 124.

Poisonous Bitter of the Karaka Nut.—SKEY states that the kernels of the karaka tree (*Coryncarpus lævigata*) are much used for food by the natives of New Zealand after being subjected to a sort of baking and washing, to free them from a poisonous constituent. This substance does not seem to be of the nature of an alkaloid, but it has the character of a glucoside, and in some respects resembles digitaline. The physiological effects of the incautious eating of the raw fruit are very marked: spasms and convulsions, with outstretchings of arms and legs, flushing, protrusion of eyes and tongue, without vomiting, are first produced; with large doses these quickly terminate in death; with smaller doses the sufferers recover; but in some instances the limbs become perfectly rigid and fixed in most curious positions for life. The treatment adopted to prevent this is to bury the sufferer (usually a child) in a pit dug in the soil up to the chin, the arms and legs being bound in their natural position, and a gag being placed in the mouth to prevent the tongue being bitten through. Sometimes the patient is repeatedly dipped in the sea before being thus "pitted." *Chemical News, xxvii.* 190.

Poisonous Properties of Calcium Salts.—RABUTEAU and DUCOUDRAY find that when calcium chloride is injected into the veins of dogs, it produces results closely akin to those noticed in the potassium chloride; *i.e.* the calcium salts act (like the salts of all other metals save sodium and lithium) as a muscle poison. When only a dose, not rapidly fatal, of calcium chloride is given, the heart's action becomes accelerated for a time, retardation being produced later on. *Comptes Rendus, lxxvi.* 349.

Arsenic in Green-coloured Envelopes.—VOGEL states that he has examined envelopes tinted green, and bought in Munich, and found that Schweinfurth green was the pigment employed. The presence of arsenic and of copper is easily detected in these articles, the sale of which should be restricted on sanitary grounds, just as the use of this pigment for carpets, wall hangings, &c. &c., is forbidden (not in England, unfortunately. —ED.). Green chromium pigments, which are harmless, can readily be substituted for poisonous arsenical preparations; the author has, however, not examined any specimen of tinted paper without finding arsenic in it. *N. Repert. Pharm. xxii.* 166.

Transportable Odourless Earth-Closet.—E. COHN, of Berlin, has constructed an earth-closet which dispenses with springs, and in which the solid excrement is collected separately from the fluid portion. Earth—best one rich in clay or coal-ash (but not sand or wood-ash)—is used as disinfectant. *Dingler's Polytech. Journal, ccvi.* 69.

Disinfection in New Orleans.—The most frequently employed disinfectant and deodorant is a mixture of zinc and iron chlorides obtained as a bye-product in the process for recovering tin from tinners' waste; a pint contains about 6½ grains of zinc chloride and 5 of ferrous chloride; it is sold (wholesale) for 50 cents. per gallon. Lime is not to be recommended as a disinfectant, most putrescent matters being already alkaline. Other disinfectants—such as Terry's (containing 14 per cent. of copperas, 20 per cent. crude carbolic acid, and a trace of zinc sulphate), bromo-chloralum (chloralum and bromide of sodium), and Terry's Egyptian disinfecting powder (baked clay with 2·5 per cent. of carbolic acid and 0·7 of sesquioxide of iron) have been tried, but do not possess any special virtues or advantages.

Carbolic acid is recommended as a disinfectant for all cases of yellow fever; it does not appear to affect sugar injuriously when used to disinfect ships loaded with that substance. *Annual Report of Board of Health to the General Assembly of Louisiana. New Orleans*, 1873.

Carbolic Acid Paper.—HOMBURG impregnates paper with 100 grammes of carbolic acid per cubic foot by melting together 5 parts stearine, 6 parts paraffin, and 2 parts carbolic acid, and dipping the paper into the fused mixture, or brushing the mixture over the paper. Such prepared paper can be used to disinfect the air, and is employed in America for the purpose of enveloping fresh meat. *Journal de Pharm. et Chim. xvi.* 363.

Trimethylamine as a Remedy for Ague, Rheumatism, and Febrile Ailments.—This alkali has been employed (frequently under the erroneous name of propylamine) in the treatment of rheumatism, acute and chronic, and of other allied complaints, as early as 1854. Avenarius employed it for this purpose; recently Gaston, Namias, and Dujardin-Beaumetz have also used it. Gubler reports that he considers that it exerts a favourable action in cases of rheumatism and where the circulating system is affected. The substance is extracted from herring-brine. *Moniteur Quesneville*, 1873, 361.

§ 5.—*Fuel, Illumination, Photography, etc.*

Products of Distillation of Brown Coal.—NIEDERSTADT has examined the action of heat on various kinds of brown coal and lignites. Between 4 and 5 per cent. of tar was collected in each case, and from 48 to 55 per cent. of aqueous distillate; combustible gases were evolved, and a coke left behind. From the tar carbolic acid was obtained with hydrocarbons; pyrol and pyridine bases were amongst the distillation products. The gases evolved contain:—

Hydrogen	41·26
Carbon oxide	40·12
Marsh gas	10·29
Nitrogen	4·09
Carbon dioxide	2·10
Olefines and condensible hydrocarbons	2·13
	99·99

Chem. Centralblatt, 1873, 154.

Production of Wood Charcoal.—STRIPPELMANN and BECKER have made a series of experiments, the results of which may be summed up in the following observations:—

1. Air-dried wood from a full-grown fir (*Pinus sylvestris*) yields a coal about 10 per cent. heavier than that from pine-wood (*Pinus abies*); but the amount obtained from fir is about 16 per cent. less than from pine.

2. Fresh pine-wood gives a coal about 10 per cent. heavier than that from air-dried wood, but the yield in the first case is 16 per cent. less than that in the second.

3. The same kind of wood yields less charcoal by 8 to 10 per cent. according as the ground on which the charring operation is executed is loose or hard and stony.

4. Where the ground is somewhat damp a coal, heavier by 3 to 5 per cent., and of correspondingly diminished amount, is obtained.

5. When the wood is piled up high, a certain amount of coal is lighter than when the heaps are lower.

6. Of several heaps (charcoal-kilns), that one gives the best results which is finished on the eighth day. Too slow burning diminishes the weight of the finished coal, as well as too fast charring by a strong fire.

7. Kilns containing about 6,500 to 7,500 cubic feet (Austrian) give the best results.

8. About 6,500 cubic feet of wood charred in seven days thirteen hours give 59·3 per cent. of coal by bulk and 25·3 per cent. by weight. The same quantity of wood yielded, when the operation lasted eight days nineteen hours, 60·7 and 25·0 per cent. respectively. *Oesterr. Zeitschr. für Berg- und Hüttenwesen, No.* 29 *und* 30. *Dingler's Polytech. Journal, ccvi.* 80.

Utilization of Fuel in the form of Dust.—C. SCHINZ describes various methods adopted for the above purpose, and especially the furnace arrangements proposed by *Crampton* in this country, and *Whelpley* and *Storer* in America. The first has been fully described by *W. Maw* in "Dingler's Polyt. Journ.," cc. 358, and the second by *C. C. Dutton* in the "Journal of the Franklin Institute," lxi. 377 and lxii. 17. Both methods for burning coal-dust are favourably spoken of. *Dingler's Polyt. Journ. ccvi.* 125.

Petroleum in Alsace.—Petroleum has been found at Schattweil, in Alsace, at a depth of 150-160 ft. Also at other places in the forest of Hagenau. It appears to be of quality equal to that of American oil. *Bayerisches Ind.- und Gewerbe-Blatt*, 1873, 30.

Method of Testing Inflammability of Petroleum, &c.—VAN DER WEYDE suggests a very rough method, consisting of the use of a graduated glass tube filled with the oil, &c., to be examined, and inverted in a vessel of water at a temperature of 43°3-44. By noticing the volume of vapour given off at this temperature a rough idea may be gained as to the relative inflammability of the sample operated on. *Zeitschrift, Annal. d. Chemie, xi.* 338.

Oils.—GLAESNER gives the following tables of the properties of various kinds of oils :—

Action of Potash in the Cold.—Five vols. oil and one of potash of sp. gr. 1·34 are agitated together. The mixture turns :

White—Almond, best rape, bleached olive.
Yellowish—Poppy, olive, rape, sesame.
Greenish — Linseed, hemp; oils coloured or containing copper.
Rose—Refined rape.
Brown or compact—Hemp.
Yellow—brown and liquid—Linseed.
Red—Whale.

Solubility in Alcohol—

Olive	1 : 1
Poppy	1 : 25
Hemp	1 : 30
Linseed	1 : 40
Almond	1 : 60

	Specific Gravity.	Melting Point.
Poppy	0·913	
Rape	0·913	— 6°
Brassica Campestris	0·914	— 4°
Almond.	0·914	— 20 to — 25°
Olive	0·918	+ 2·5°
Sesame.	0·923	— 5°
Sunflower	0·926	— 16°
Castor	0·950 to 0·960	— 18°
Linseed.	0·930	— 16° to — 20°
Hemp		— 27°

Archive der Pharmacie, ccxix. 201.

Influence of Coloured Light on Exhalation of Carbonic Acid.—SELMI and PIACENTINI exposed a dog to light of various colours, and determined the amount of carbonic acid evolved in a given time, with the following results :—

White light	100
Darkness.	82·07
Violet	87·73
Red.	92
Blue	103·77
Green	106·03
Yellow	126·83

It would hence appear that the rays most favourable to the absorption of carbonic acid by plants also promote its exhalation by animals. *Industrieblätter, ix.* 364.

Photography by Ferrocyanide Paper. — Paper soaked in solution of ferrocyanide of potassium is altered by light, so that a blue substance (Prussian blue) is deposited where the light acts ; by simply washing the paper the unaltered ferrocyanide is removed and the photograph rendered permanent. Prepared paper for this purpose is sold under the name of *papier marion.* The exposure must be prolonged until the picture first appears and then becomes almost effaced, a grey tint with a metallic reflection being produced ; the washing must be continued until all coloration is removed from the whites of the picture. *Les Mondes, xxx.* 262.

Carbon Pictures on Gypsum or Ceramic Plates.—R. JACOBSEN states that paper prepared with bichromate is exposed for a sufficient time under a transparent drawing, woodcut, &c., and the excess of chrome salt removed by washing. The paper is then transferred, picture-side down, to a plate of gypsum. A positive copy is thus obtained from a positive drawing, as only the unchanged gelatine sinks into the gypsum. By substituting for the carbon enamel colours, designs can be printed on and burned into unglazed porcelain, &c. *Jacobson's Chem. Techn. Repert. Dingler's Polyt. Journ. ccvi.* 76.

Gummate of Iron Paper.—Paper is soaked in a filtered solution of ferric chloride, to which ammonia has been added in such quantity as to throw down a small amount of precipitate which redissolves on agitation ; the paper is then dried in the dark, and covered with thick solution of gum arabic. When dry this paper remains flexible for a long time, and has a glistening surface. *Les Mondes, xxx.* 261.

Varnish for Photographic Negatives. — KRÜGER considers that all acid and gummy constituents should be removed from resin by treating it with soda before it is dissolved in alcohol to form photographic varnish. *Polytech. Notizblatt, No.* 20.

6. *Electricity and Telegraphy.*

New Form of Noes' Thermo-Electric Battery.—WALLENHOFEN bends back at an acute angle the negative wire connected with the positive metal, and fixes a small metallic rod to this junction. Twenty of these couples are then arranged in a circle so that the metallic rods all radiate out from the centre. All the rods are then heated by a circular gas flame, a mica plate being placed over the centre. Twenty elements have an electro-motive force equal to 19·4, that of a Bunsen's cell being 20 ; *i.e.* the electromotive of a single element force is nearly $\frac{1}{20}$ of a Bunsen's cell or $\frac{1}{12}$ of a Daniell's. The resistance of each element is 0·056. *Chemisches Centralblatt,* 1872, 530.

New Air-Battery.—GLADSTONE and TRIBE describe a new battery consisting of two metals immersed in a solution of a salt of the more oxidizable one of them, the solution containing dissolved air or oxygen. The more oxidizable metal is dissolved, and its oxide deposited on the other metal, a current being produced, the strength of which varies with the temperature, the amount of oxygen dissolved in the fluid, &c. &c. With plates of silver and copper, and an aerated solution of copper nitrate it was found that little advantage is gained by increasing the size of the copper plate, the silver plate remaining the same ; on the other hand, if the silver plate vary in size, the copper remaining the same, an increase in power results nearly proportionate to the increase in size. Suboxide of copper is thrown down on the silver plate, if the strength of the copper nitrate be not more than 6 of nitrate in 100 of solution ; if stronger, a "basic nitrate" is apt to be deposited. The internal resistance of this battery is small ; its electromotive force is $\frac{1}{3}$ or $\frac{1}{10}$ of a Daniell's cell. A similar battery with plates of zinc and copper, and charged with an aerated solution of zinc chloride (which has less resistance than the sulphate) has a higher electromotive force, about $\frac{3}{4}$ of a Daniell's cell. Batteries of this kind might be used where the work was frequently interrupted, as the dissolved air which becomes used up during working, would be spontaneously renewed during rest ; the chief objection would be the great decrease in power observed after working for a short time, as the dissolved oxygen becomes exhausted. *Proceedings of the Royal Society, xxi.* 247.

Curious Galvanic Actions.—RAOULT finds that a plate of copper and one of cadmium immersed in a solution of cadmium sulphate deprived of air, and covered with a layer of oil, immediately give rise to the deposition of cadmium on the copper plate when the two plates are brought into contact by suitably moving the containing vessel. *Comptes-Rendus, lxxv.* 1103.

RAOULT also finds that a gold-cadmium couple immersed in a boiling concentrated solution of cadmium sulphate or chloride causes the immediate deposition of a closely adherent film of cadmium on the gold. The action is most rapid with a *neutral* solution ; cadmium nitrate does not produce the same result. Similarly a gold-zinc couple decomposes sulphate or chloride (but not nitrate) of zinc, this metal being deposited on the gold ; a gold-tin couple also decomposes stannous chloride ; gold-iron, gold-nickel, gold-antimony, gold-lead, gold-copper, and gold-silver couples, on the other hand, produce no action on being immersed in cold or boiling acid or neutral solutions of the metal in contact with the gold, even though hydrogen be evolved.

The amount of metal thrown down is in all cases small; it appears to constitute an alloy with the gold. Copper may be substituted for gold in the case of gold-cadmium, gold-zinc, and gold-tin couples. *Comptes-Rendus, lxxvi.* 156.

New Insulator.—H. HIGHTON states that vegetable tar (from what plants, and how prepared?) becomes almost instantly solidified by admixture with oxide of lead, or in a less degree with other substances, and that the solid so prepared has great insulating powers. *Chemical News, xxvii.* 218.

§ 7.—*Miscellaneous.*

New Explosives.—HOUZEAU finds that by acting on benzine with ozone, a body which he terms *ozobenzine* is formed ; this is a white amorphous solid, which is decomposed with great violence when gently heated. Olefiant gas detonates with violence on being brought into contact with ozone. The author suggests that so-called spontaneous explosions and fires may sometimes be caused by the action of atmospheric ozone. *Moniteur Quesneville,* 1873, *April.*

SPRENGEL states that various mixtures of oxidizable substances and nitric acid, or of chlorate of potassium, and combustible liquids have an explosive power much greater than that of gunpowder, and comparable with that of nitroglycerine. Mixtures of the nitro-derivatives of this hydrocarbon and of nitric acid sp. gr. 1·5 appears to be convenient ; thus picric acid (trinitro-phenol),

nitrobenzol, and analogous substances, explode violently when fired by a detonating cap. A porous cake of chlorate of potassium saturated with carbon disulphide is five times as effective as the same weight of gunpowder when tested in open granite quarries. One great advantage possessed by substances of this kind is that materials, which when mixed form an explosive substance, are separately perfectly safe so far as explosive power is concerned; whilst the admixture can be made with great ease and safety. *Paper read before the Chemical Society, May 1st*, 1873.

Comparative Force of various Explosives.—BERTHELOT has examined the quantity of heat developed by the combustion of various explosive mixtures, and the volume of gas generated in each case; the relative pressures developed on firing are as follows:

Hunting powder	1·
Cannon	0·986
Mining	0·633
„ with excess of nitre	0·540
Powder with nitrate of soda as base	1·368
„ „ chlorate of potash	2·225
Nitrogen chloride	0·842
Nitroglycerine	6·797
Gun-cotton	3·636
„ mixed with nitrate	3·456
„ „ chlorate	4·594
Picric acid	3·910
„ mixed with nitrate	2·722
„ „ chlorate	4·198
„ „ oxide of lead	0·108
„ „ copper	0·785
„ „ silver	0·208
„ „ mercury	0·288
Picrate of potash	2·476
„ mixed with nitrate	2·059
„ „ chlorate	3·574

Annales de Chimie et Physique.

Suint.—SCHULZE states that suint contains cholesterine and fatty acids but no glycerine, thereby confirming the statements of Chevreul and of Hartmann. *Berichte des Deut. Chem. Gesellschaft, v.* 1075.

Varnish from Vulcanized Rubber.—Refuse vulcanized rubber is melted in a covered iron vessel, and then poured out on a grease plate; the cake is broken up and dissolved in benzene and turpentine with frequent agitation. *Industrieblätter.*

Detection of Water and Alcohol in Ether.—BOTTGER states that perfectly anhydrous ether will mix with carbon disulphide, forming a perfectly clear solution, whilst ether containing water gives a milky liquid. The presence of alcohol may be known by shaking up the ether with a piece of caustic potash; if alcohol be present, some of the potash is dissolved, and the solution acquires a yellowish colour on standing for twenty-four hours. *Chem. Centr.* 1872, 742.

Detection of Alcohol in Chloroform.—OUDEMANS treats a known quantity of the chloroform with pure dry cinchonine, keeping the whole at 17° C. for some time; finally, the solution is filtered, and the filtrate evaporated to dryness. According as more or less alcohol is present in the chloroform, a greater or less residue is left; with pure chloroform, 5 cubic centimetres leave 21 milligrammes of residue, with 10 per cent. of alcohol, 366 milligrammes are left. *Chem. Cent.* 1873, 184.

Preparation of a Good Adhesive and Durable Paste.—F. SIEBURGER gives for this the following prescription:—Four parts by weight of glue are allowed to soften in 15 parts of cold water for some hours, and then moderately heated till the solution becomes quite clear. Sixty-five parts of boiling water are now added with stirring. In another vessel 30 parts of starch paste are stirred up with 20 parts of cold water, so that a thin milky fluid is obtained without lumps. Into this the boiling glue solution is poured, with constant stirring, and the whole is boiled. After cooling, 10 drops of carbolic acid are added to the paste. This paste is of extraordinary adhesive power, and may be used for leather, paper, or cardboard with great success. It must be preserved in closed bottles, to prevent evaporation of the water, and will in this way keep good for years. *Dingler's Polytech. Journal, ccvi.* 248.

American Leather-cloth.—The mode of manufacturing this cloth is the following:—A piece of cotton texture is passed between two cylinders, the upper one of which permits a mixture consisting of oil, resin, lampblack, and other matters to flow upon the slowly moving canvas. From the cylinders the fabric is wound up upon a drum made of wooden sticks so arranged that the successive layers are kept apart from one another. When the whole piece has been wound up on the drum, the latter is placed, with the oiled cloth on it, in a drying chamber. After drying, the cloth is smoothed by means of pumice-stone, and passed a second time through the cylinders, receiving another coating of varnish. It is then dried, and these alternate operations repeated at least five times, in order to make the coating sufficiently thick. The final process is pressing the cloth in such a manner as to give it the appearance of natural leather. *Wochenschr. nieder-oester. Gew. Ver. Polytech. Centr.* 1872, 1296.

Good Varnish for Wicker-work.—F. RHIEN recommends the following composition for the above purpose. One part of good linseed oil is boiled down to a syrupy consistence, and mixed with 20 parts of copal, or some other rich lac. This mass is then diluted with oil of turpentine to the proper thickness. This varnish dries easily, and remains sufficiently elastic to stand without cracking the bending of the baskets, &c. *Polyt. Centr.* 1872, 1303.

THE PLOUGH—ITS HISTORY, CONSTRUCTION, AND MANAGEMENT.

IN our second article under this head (p. 361, Part 5) we devoted the latter portion to a consideration of the influence which the mouldboard exerted upon the form of the furrow-slice. Some writers treat of this part of the plough as if it alone gave the peculiar form to the furrow-slice, and that the peculiar features of this were derived exclusively from the curves which were given to the surface of the mouldboard. This also, we may remark in passing, is the popular notion as to the office which the mouldboard is called upon to perform. But while it is true that the form of the furrow-slice is greatly influenced by that of the mouldboard, it is no less true that the coulter and the share also influence this shape or form; indeed, it might also be affirmed that the greatest influence is exerted upon the form of the furrow-slice by these two last-named members of the plough. Let the fact be kept steadily in view, that the mouldboard turns over or inverts the slice which the share and the coulter cut from the soil, and thus prepare the slice for the mouldboard to invert. But it will be obvious, on further investigating the point, that apart altogether from the form of the mouldboard and the nature of the curves which make up its surface, the furrow-slice will have a determinate character or form given to it by the manner in which it is cut from the soil. If the reader will turn to the illustration given in fig. 17 in our second paper, he will see that the slices turned over by the mouldboard give a series of exposed surfaces which are angular, all of which are of equal breadth; and this is obtained by so arranging the form of the furrow-slice that the ends are at right angles to the sides. But it is obvious that if the slice were so cut as no longer to have the sides in this relation to the ends, the angles presented or left to the action of the atmosphere, after being turned over by the mouldboard, would assume a different shape, and in place of being as at *a a* in fig. 18, they might be of the form as at *a a* in fig. 19; and the projecting or angular parts in *a a*, fig. 19, would obviously enclose cubical contents different from those which would be enclosed by the angular parts in *a a*, fig. 18, as will be seen by the dotted line, *b c*, drawn across parallel to the soil, and at the same height from the bottom of the furrow-slice. We shall see, farther on, that this peculiar bulging out, so to call it, of the upper part or angles in fig. 19 is to a certain extent produced by the action of the mouldboard. We proceed now to point out how this peculiar form is impressed, so to say, upon the furrow-slice by the cutting parts of the plough, the "share," and the "coulter." Suppose the furrow-slices, of which *a a* in figs. 18 and 19 are the angular or upper parts left after the mouldboard has performed its work, to be laid flat on their broadest sides, they would assume the form of *a b c d* in figs. 20 and 21. In the one case, fig. 20, we have the section of a rectangular solid, in the other the section of a rhomboidal or trapezoidal solid. Drawing a line, *e f*, in both cases at the same angle, and the cutting or entering points *e e* being at the same distance from the points *b b*, we have another illustration of the fact shown in figs. 18 and 19, that the cubical contents of the angular parts are different, the lines *e f*, *e f*, in figs. 20 and 21, corresponding to the lines *b c*, *b c*, in figs. 18 and 19. Supposing the

upper surfaces *a b* of the slices, figs. 20 and 21, to be formed by a shaving or cutting operation; if the section of the cutting implement was such as to have its lower surface, as *a b*, namely, that which would come in contact with the upper surface, as *a b* of the slice on fig. 20, this upper surface would obviously be flat and parallel with the lower surface *d c*. But if the section of the cutting implement were such that its lower surface presented the line *a b*, fig. 23, the implement being held so that its upper surface *c d* were parallel to *c d*, fig. 21, then it is obvious that the upper surface shaved or sliced off would assume the form of *c d* in fig. 21. Reverse the position of the cutting implements in figs. 22 and 23, so that they will be under the slice in place of above

Fig. 18.

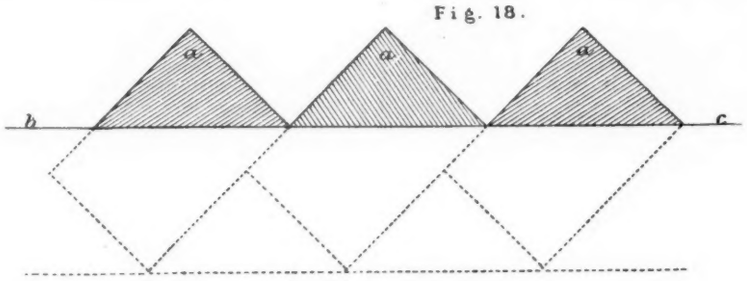


Fig. 19.

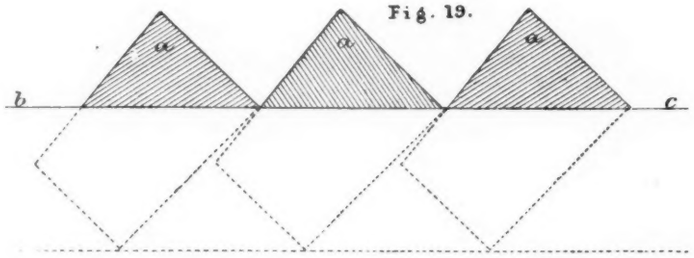
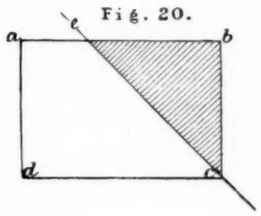


Fig. 20.



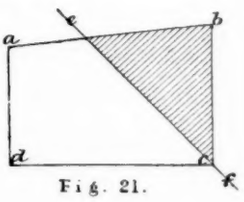
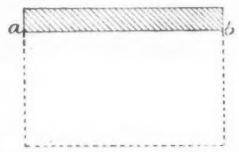


Fig. 21.

it, and the positions will be as in figs. 24 and 25. Suppose, in fig. 24, *a b c d* to be the section of the "share" of a plough; the forms of the slices cut off by the shares would be as at *a b c d*

Fig. 22.



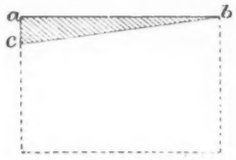


Fig. 23.

in fig. 24, and as at *a b f e* in fig. 25; turn these slices over by a mouldboard, and the angular parts left exposed to the action of the atmosphere would be, in the case of fig. 24, as in fig. 18, and in the case of fig. 25, as in fig. 19. And this difference in the form of the furrow-slices would be obtained by means altogether independent of the action of the mouldboard, the office of which would be simply turning over or inverting the slices cut off and so

Fig. 24.

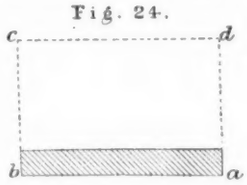
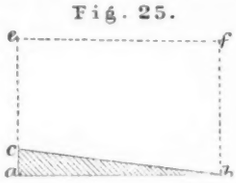


Fig. 25.



formed. And some of our readers may not be prepared for the statement that this turning over, or inversion of the furrow-slice, is not dependent upon the screw-wedge or curved form of the mouldboard, as some suppose, but may be performed by a mouldboard perfectly flat or rectangular, or nearly so, in its section, as we see exemplified in the Kentish or "turn-wrest" plough, hereafter to be described. But up to the present point of our investigation into the means by which the furrow-slice has its form given to it, we have only considered the action of the "share" which gives the horizontal cut, separating the furrow-slice at the bottom from the lower part of the soil, technically called the "sole." We shall now find that the form of the furrow-slice is influenced by the action of the "coulter," which cuts the slice vertically, separating it from what is technically called the "land side," and which is always towards the left hand of the ploughman, the mouldboard being at the right hand. We should here point out that the share does not completely separate the bottom of the furrow-slice from the sole; a portion towards the right hand, or towards *c*, as in fig. 20, being always left uncut, this being torn away or wrested by the mouldboard. But on this we shall have yet to remark. The influence of the coulter upon the form of the furrow-slice will be seen by inspecting figs. 26, 27, and 28. Thus, if the coulter *a a*, fig. 26, be "set" so that it is exactly at right angles to the line of sole

Fig. 26.

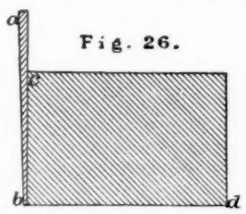
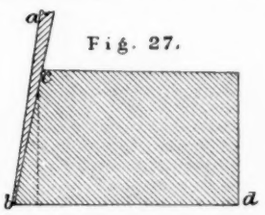
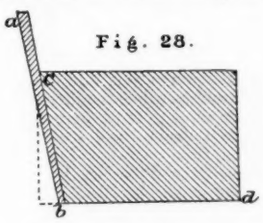


Fig. 27.



a b, it is clear that the end *a c* of the furrow-slice will be at right angles to *a b*; but if the coulter has a "set" so that it inclines to the "land side," as *a b* in fig. 27, it is obvious that the end *b c* of the furrow-slice will not be at right angles to the side *a b d*, but will be angular, as shown. If the coulter, however, be "set" so that it inclines towards the "furrow side," as *a b* in fig. 28, the

Fig. 28.

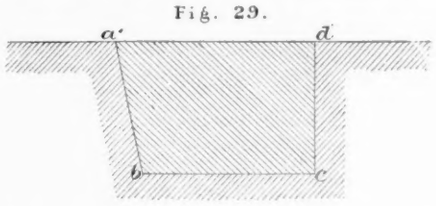


end *b c* will be angular, but in the opposite direction from that in fig. 27. The "set" given to the coulter is always in practice given to the furrow side, as in fig. 28, thus leaving the land side with a sloping side *a b*, as in fig. 29. In this fig. *a b c d* shows the furrow-slice, which, when turned over and made to assume its proper position by the mouldboard, will naturally give a projecting

surface at the angle *a* different from that of the rectangular slice as at *a a*, fig. 18. Furrow-slices as at *a a*, fig. 19, and at *a*, fig. 29, are termed "crested" or "high-shouldered;" and at one time controversy ran high as to the comparative merits of these two forms of slices. Those curious in the matter will find the subject fully investigated in the "Book of Farm Implements and Machines," published by Messrs. Blackwood and Sons.

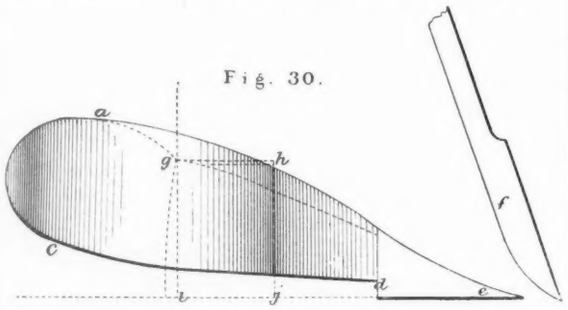
We thus see that, independently of the mouldboard, the furrow-slice in its form is influenced by the action of the coulter and the share; but this being so, it is not to be supposed that the mouldboard has no influence on the form. The extent or amount of this influence depends upon the lines or the contour of the face of the mouldboard over which the furrow-slice passes. If the contour is such as to give a short, abrupt, and convex form to the mouldboard, then the furrow-slice will be acted upon in such a way that the upper corner is squeezed out or bulged out, so to say, giving a high crested slice. If the lines of the mouldboard are fine, giving a long, easy, and concave surface, then the slice is little pressed upon by the mouldboard, and it therefore retains the original form given to it by the coulter and the share; which, we presume, in this case to be so set as to give a rectangular slice, as in fig. 24. It will be here useful to trace the movements of the mouldboard through

Fig. 29.



the soil; and at this point will be seen the use of the share being so arranged that it does not cut or sever the furrow-slice wholly from the sole. If the slice were severed completely from the soil, the natural tendency of the forward action of the mouldboard would be to shove the slice before it and aside, the result being a compound of these two movements. But the slice being still connected with the soil at its extreme end nearest the share, a point of resistance is reserved which gives, on the one hand, the slice a tendency to keep up and against and move along the curved surface of the mouldboard, while, on the other hand, the unsevered part serves as a fulcrum, round which the slice turns as the mouldboard passes onward; and this, when the slice is about to receive its last position, tears or wrests the slice from the soil. If the reader will turn to our second paper in last number, and referring to the illustration in fig. 16, repeat the experiment with the belt there explained, he will see that while the turning over is being performed, it is essential that the belt must be held fast at one point, otherwise the turning over cannot be completed, the belt merely slipping forward and aside. In this experiment the fingers or palm of the hand must be placed under the belt, and moved forward to represent the forward action of the mouldboard. In afterwards describing the special features of the share we shall show how in practice this is placed, the "pitch" which is given to it, and how this pitch is adjusted. We are now in a position to trace the movements of the mouldboard through the soil. As it is pulled through the soil by the power of the horses, the furrow-slice, which has been cut by the share and the coulter, passes up and over the curved surface of the mouldboard, assuming a variety of positions, till it is finally turned over at the angle as shown in fig. 17 (see article in No. 5, p. 361), and while thus passing the lower edge of the land side of the slice, describes a certain line. On the supposition that the height of the mouldboard, measured from the sole or under surface of the soil on which the plough body slides along, was uniform from the point nearest the share to that nearest the ploughman, this line described by the edge of the furrow-slice would be a line parallel to the sole. But as the reader—whom we suppose to be here studying for the first time the features of the plough—will see on examining fig. 15, and who will indeed, from our other illustrations and remarks previously given, have learned the fact that the mouldboard is a body which, beginning at the low level of the share, gradually rises upwards and spreads outwards, the edge of the furrow-slice, as it passes over the surface of this varying outline of mouldboard, will describe also a varying line, and that depends upon the form of the mouldboard surface. On examining the diagram in fig. 17, the reader will observe that at one part of its movements the furrow-slice assumes a perfectly vertical position, standing on end, in fact. While in this position the upper edge of the slice—which was that originally connected with the soil, and is therefore called the "land-side"—is by consequence at its highest line on the surface of the mouldboard; and that line should be distant from the outside surface of the "land-side" of the plough body a length or space precisely equal to the breadth, as *c d*, fig. 24, of the furrow-slice. In constructing and analyzing the lines of mouldboards, a line drawn through this point is known technically as the "zero line," the use of which will be afterwards explained. In fig. 30 we give a diagram illustrating the points above stated; *a b c d* is the side elevation of a mouldboard, with the share *e* and coulter *f*; the dotted line *b g a* may be assumed to be the line described by the lower edge of the land-side of the furrow-slice as it passes over the surface of the mouldboard *g h i j*, the furrow-slice standing vertically, *g i* being the "zero line" and *g* the "zero point." In fig. 31 we give the plan, and assuming the point *a* to be the

Fig. 30.



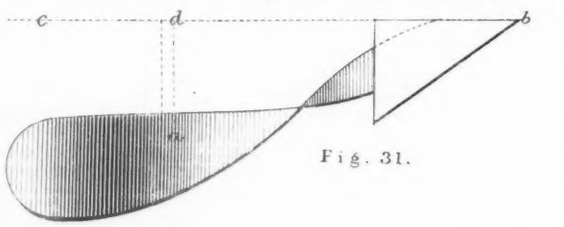


Fig. 31.

zero point corresponding to *g* in fig. 30, and *b c* the "land-side" of the plough body, the distance from the "zero point" *a* to *d* on the line *a b* is equal, as stated above, to the breadth, as *g i*, fig. 30, or *c d*, fig. 24, of the furrow-slice at the point where the furrow-slice assumes the vertical position, as in fig. 30. We have in the above remarks spoken of the passage of the furrow-slice over the surface of the mouldboard. This is of course not correct, the land or slice remaining stationary so far as motion in the direction of the plough is concerned; but we have used this mode of expression to give the reader a clearer view of the operation. The mouldboard, however, being forced or driven through the soil, it is obvious that, independent of the peculiar curves which it assumes, the formation of that surface in the direction of the line of draught will exercise an influence upon the draught, or the ease or otherwise with which the mouldboard can be drawn through the soil, all inequalities in the direction at right angles to the line of draught being therefore so much loss. While, therefore, the lines transversely to the length of the mouldboard are varying, giving a varying surface to it, the surface in the longitudinal direction must be straight and uniform. In a well-constructed plough, a straight-edge, as *a b*, fig. 32, placed along the mouldboard, should touch all the

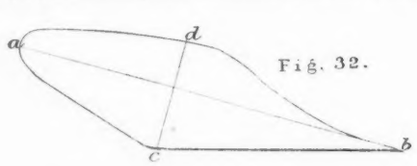
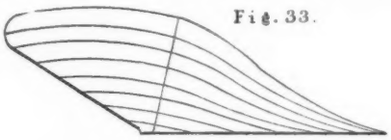


Fig. 32.

surface; and although the outline of the section varies throughout the length, still the transverse surfaces should be such that lines laid at any point, as at *b c*, in fig. 32, should also touch all parts of the surface. Thus an absolute uniformity or evenness of surface is required in a mouldboard, the object being that no obstacle or protuberance be presented to the furrow-slice as the mouldboard slides along it; this is considered by all authorities as an essential feature in all mouldboards, no matter what their contour be, the only exception to it which

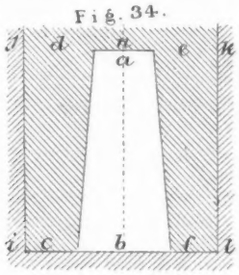
we have as yet been made acquainted with being that of an American inventor, who claims to have an intimate knowledge of the plough, and who asserts that practical experience has shown him that "the surface of the mouldboard should be a curve, as shown by a straight line drawn from the forward point on the lower side of the mouldboard diagonally to the upper end. This line will be one inch above the surface in the middle. Lines drawn at right angles on this line, as *a b* in fig. 33, will be one quarter of an inch above the surface, and that

Fig. 33.



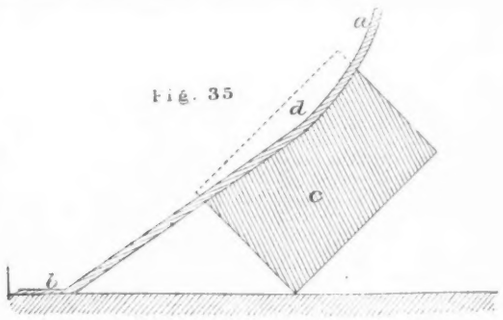
the furrow-slice will follow the curved lines indicated." An examination of the form of the mouldboard of a plough will suffice to show that the furrow-slice must be pressed upon more or less by the mouldboard, and that this squeezing process will be increased in intensity as the swelling or bulging out part of the mouldboard is increased. The diagram in fig. 34 illustrates this simply; the further the wedge *a b* is pressed into the space between two portions of soil, as *c d e f*, held between two immovable or fixed parts *i j*, *k l*, the greater will be the compression of the parts *c d*, *e f*; the maximum points being at *c* and *f*, where the wedge is thickest at *b*. If only half a wedge is used, as that part on the side *c f* of the centre line *m m*, the result would be the same so far as the half *e f* was concerned; the half wedge might be considered as the mouldboard of the plough and *e f* the furrow-slice. The case, however, is not a parallel one so far as the actual operation of ploughing is concerned, because the furrow-slice is not held fast, as we suppose the soil *e f* in fig. 34 to be held, but "gives" laterally, or moves away from the mouldboard in a certain proportion. Still the squeezing or pressing process is effected by the mouldboard of a plough much in the same way as illustrated in fig. 34. And it

Fig. 34.



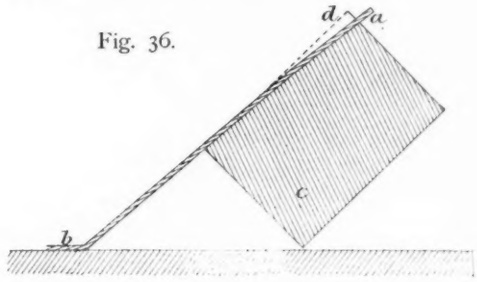
is obvious that the greater the degree and the rapidity—so to say—with which the mouldboard is made to bulge outwards, the greater the proportion of the pressure to which the furrow-slice is subjected. Thus, let us suppose *a b* in fig. 35 to represent the sectional (cross) part of a mouldboard at the point where it is about to leave the furrow-slice laid over in its final position, the slice *c* will be left uninfluenced by the mouldboard. This represents the case of a mouldboard the contour of which is

Fig. 35.



concave and the length considerable, so that its "lines" are long and easy, and no abrupt swelling out or curve is met with. But if we take the case as illustrated in fig. 36, where *a b* represents the section of the mouldboard, in relation to the furrow-slice *c d*, as it is about to leave it in its final position, thus representing a short and convex mouldboard, we shall find the result to be different. In fig. 35 the mouldboard, with its easy lines and fine contour, in the last portion of its contact acts only upon the small portion shown by the dotted lines at *d*, tending either to bulge the upper portion out if the soil is of a clayey, adhesive character, or to pulverize it if it is short and friable. But in the case illustrated in fig. 36, the portion *d* in dotted lines extends down all the side of the slice, and a considerable portion is left to be either squeezed out, so as to form a "high crested" slice, or to pulverize it. We have here touched

Fig. 36.



upon one of the disputed points in ploughing, there being two "schools," so to say: one strenuously insists that the efficiency of ploughing is shown by the way in which the furrow-slice is left, this being "turned over in a perfectly straight line, not only unbroken, but uncrushed;" the other school as strenuously insisting that the object of ploughing is not only to invert the soil, thus burying the weeds, &c., but that after inversion it should be left in a broken up and pulverized condition. These two views carry with them so many points of importance that their discussion cannot be left to the brief space at the end of a paper which has already extended itself beyond the limits we gave when we commenced it. We must therefore leave it to a succeeding paper. Up to the present point we have endeavoured to show how the furrow-slice is formed, and what are the agencies by which that formation is brought about. We have next to concern ourselves with the methods adopted in practice by which these various parts are constructed, and how they are fitted to the plough.

PNEUMATIC DISPATCH—PASSENGER, POSTAL, PARCEL, AND TELEGRAPHIC.

THAT system which is awkwardly called *Pneumatic Dispatch*, but which would be better designated *Pneumatic Transmission*, has become very remarkable in connection with postal and telegraphic service, and bids fair to be marked by important extensions in future. Its history is well worthy of notice, seeing that the first idea was to *blow passengers along*, instead of dragging them by horses, by rope traction, or by locomotives.

So far back as 1810, Mr. Medhurst, a mechanical engineer settled in London, published "A New Method of Carrying Letters and Goods by Air;" but the few persons who read the pamphlet smiled at it as a chimera. A few years afterwards Mr. Vallance, of Brighton, described in a pamphlet a possible mode of conveying passengers through a large tube of iron or a tunnel of brickwork. Rails were to be laid down in the tunnel, and a carriage propelled along it—not by condensed air pressing from behind, but by a partial vacuum in front of the carriage. The plan was patented in 1823, and its possibility demonstrated on a small scale; but Mr. Vallance found no capitalists willing to take up the subject. In 1827 Mr. Medhurst again entered the field by the publication of a pamphlet on "A New System of Inland Conveyance for Goods and Passengers." His inventive brain had been very fertile. He described the possible arrangement of (1) a tunnel like Mr. Vallance's, with the carriages so nearly fitting it as to act like pistons, and working by the suction due to a partial vacuum (produced by an air-pump) in front of the carriages; (2), a similar system, worked by a plenum or pressure of air behind the carriages; (3) a smaller tunnel or tube, with goods trucks inside, passenger carriages over it on the outside, a curious hinged valve along the tube, an upright bar through this valve opening to connect

the two sets of carriages, and pneumatic propulsive power within the tube; (4) a small tube laid down between the two rails of a tramway, a pneumatic arrangement within the tube, an upright bar passing through a valvular opening along the tube, and an outside train of goods and passenger carriages. Mr. Medhurst did not realize any of these schemes; but his pamphlet was the means of suggesting ideas to later inventors.

We now come to the year 1835, when Mr. Pinkus patented his *Pneumatic Railway*. This was to be a strong cast-iron tube, about a yard in diameter, with a slit or open channel along the top; a soft flexible valve laid along this slit rendered it air-tight; but this valve was susceptible of being gradually lifted up to allow of the passage of a vertical bar, the bottom of which was within the tube and the top outside it. The bottom of the bar was connected with a "dynamic traveller," an apparatus that served the office of piston; the top was connected with the "governor," an apparatus to which the train of goods and passenger carriages was attached—the latter running on two rails outside the tube. It was, in fact, a working out of one of Mr. Medhurst's ideas. Trials were made on a small scale near the Kensington Canal; but capitalists still held aloof.

At length a practical attempt was made by a company of shareholders to give a fair trial to the atmospheric or pneumatic mode of propulsion. In 1840 Messrs. Clegg and Samuda brought forward their *Atmospheric Railway*. They laid down about a mile of railway at Wormwood Scrubbs near London, with a nine-inch iron tube midway between the rails, and a mechanism similar to that proposed by Medhurst for connecting a piston inside the tube with a carriage outside. Atmospheric pressure within this small tube produced a result which surprised many persons who had until then ridiculed the whole idea; one carriage with a load of 5½ tons attained a speed of 30 miles an hour; two carriages with 11½ tons 22½ miles an hour. Just about that time the Dublin and Kingstown Railway Company were planning an extension from Kingstown to Dalkey, with gradients and curves too severe to be surmounted by the locomotives of those days. Struck with the performance of Messrs. Clegg and Samuda's experimental line, the directors resolved to try the atmospheric system. This was done, and the line completed in 1843. The tube, laid midway between the rails, was 15 in. in diameter; the slit along the top was closed by a leather valve of most curious construction, the details of which occupied more thought and gave more trouble than any other part of the system. A steam-engine at Dalkey pumped out the air from the tube in front of the piston or dynamic traveller, and thereby drew the train up the steep incline (40 ft. per mile) by suction; the train descended by gravity alone; the passenger and goods carriages were connected with the piston by a strong upright bar, passing (in the way already described) through the slit in the top of the tube; and in some experimental trials the almost incredible speed of 50 or 60 miles an hour was attained.

The year 1845 was a year of madness in relation to English railways; speculation ran wild, and stupendous amounts of capital were (really or nominally) subscribed for new railways in every part of the kingdom. The little Kingstown and Dalkey experiment did not escape the notice of projectors. The London and Croydon Company determined to adopt the atmospheric system on their line; so did the South Devon Company; while new companies proposed its adoption on the Croydon and Epsom, the Direct Portsmouth, the Northumberland, and other lines. On the Croydon and the South Devon lines alone were the plans fulfilled, and most disastrous was the result. The valvular opening along the top of the tube proved to be the ruin of the system. In spite of all the skill of all the engineers, leakage through this valve could not be prevented; this leakage meant waste of power, which always means waste of money. The atmospheric system was found very costly to work; the power of the locomotive to climb pretty stiff ascents was ascertained; and gradually pneumatic or atmospheric railway traction was abandoned altogether, after several millions of money had been expended on it. Whether the railways of the future will find means to resuscitate it, the future must say.

One attempt has been made since to carry passengers *inside* a tube by air suction. In 1864 Mr. Rammell, civil engineer, prepared plans for a pneumatic railway that would achieve this singular result. He was appointed engineer to a newly-fledged company established for constructing an underground railway from the Marble Arch, through Oxford Street and Holborn, to the City. To illustrate the proposed mode of traction, he obtained permission to construct a short experimental line in the grounds of the Crystal Palace. It was a brickwork tunnel 10 ft. high by 9 ft. broad, with a single line of broad-gauge rails along the bottom; severe gradients and curves were designedly adopted to put the system to the proper tests. A carriage or omnibus to run on the rails was made to correspond in height, breadth, and form, very nearly to the cross section of the tunnel, so as almost to fit it like a piston, and was rendered practically air-tight by means of a fringe-work of bristles at one end. An exhaust-fan, worked by a steam-engine, sucked out the air in front of the carriage, thereby sucking the carriage itself along! More strictly, only a portion of the air was removed; for it was found that a very slight difference of pressure before and behind the carriage was sufficient to produce a motive power of considerable force. The carriage was roomy, well-seated, and well-lighted, and travelled to and fro in the tube smoothly and rapidly. The refusal of Parliament to sanction the new railway scheme put a stop to the adoption of this singular mode of conveyance; and there has been no further attempt of the same kind.

We now come to the *Pneumatic Dispatch*, officially so called the initiation of which preceded by a few years Mr. Rammell's achievement. In 1861 a company was formed for the transmission—not of human beings—but of parcels and mail-bags through a tube by pneumatic power. It was believed that great service would be rendered if the mail-bags arriving at Euston Station and other railway termini could be blown rapidly through a tube to the chief office at St. Martin's-le-Grand, and blown back again for the outgoing mails, instead of being conveyed in mail-carts by the more tardy mode of street travel. It was also contemplated to carry small parcels to and from the several railway stations and depôt offices; to carry professional, commercial, official, and private documents of all kinds, as well as newspapers and books, from office to office, combined with a hand-delivery to the consignees; and to lay down a series of special tubes for Government use, for the conveyance of the almost numberless messages and papers which are every day passing to and fro between the widely-scattered Government offices in Somerset House, Whitehall, Pall Mall, Palace Yard, &c. As a means of testing the mechanical capabilities of the scheme, the company laid down an experimental tube about a quarter of a mile long near Battersea Fields. It was mostly on the ground, but was raised on props here and there, in order to produce some rather sharp curves and gradients. The pipe was about 30 in. diameter, with a bee-hive section. The carriages to run inside this tube were strong cast-iron cradles or cots, with a vertical section like that of the tube, and nearly touching it on all sides; four small wheels underneath each cradle run upon a miniature railway within the tube, and two or more such cradles could be linked together into a train. A steam-engine, working an exhaust-fan 20 ft. in diameter, drew out the air, or a portion of it, from the tube. With only a partial vacuum, two carriages, weighted to 750 lbs. each, were sucked through the tube at a speed of thirty miles an hour; a much heavier train could be drawn either by lessening the speed or increasing the vacuum.

This experiment at Battersea encouraged the company to empower their engineers, Mr. Latimer Clark and Mr. Rammell, to commence operations in earnest. The small experimental tube was utilized between Euston Station and the North-Western District Post-Office at Eversholt Street, hard by, to whisk some of the mail-bags to and fro; but a large tube was planned from Euston to Holborn, with a prospective extension to St. Martin's-le-Grand. The Duke of Bedford, as a landowner, frustrated an attempt to carry the tube along the nearest route through his estate; and therefore a circuitous line was taken *viâ* Tottenham Court Road, High Street, Broad Street and High Holborn. The tube is nearly 4½ ft. in diameter, with a section nearly like that of a railway tunnel; it is laid at a small depth below the roadway, with no small disturbance of gas and water-pipes. For the most part it is of cast-iron, but some of the sharp curves are constructed of smoothly-finished brickwork. The line was finished to Holborn in 1865; the extension from that point to St. Martin's-le-Grand was delayed for some years, and was not completed until the recent construction of the Holborn Viaduct. The whole line—3,080 yards from Euston to Holborn, and 1,658 yards from Holborn to St. Martin's-le-Grand—has been ascertained to work well. A powerful steam-engine at Holborn, working an exhaust-fan, 22 feet diameter, produces a partial vacuum, so managed that the carriages are driven by air-pressure in one direction and drawn by the suction of rarefied air in the other—the whole run of 4,738 yards being accomplished in eight minutes. The tube is thus ready for working, and the company are willing to lay down branches to Charing Cross and in other directions. But where is the traffic? The railway companies and the Postmaster-General have not yet seen their way to the establishment of a commercial agreement with the Dispatch Company; and until they do so the latter have no inducement to set their tube to work. But it will not always be so. The tube is there; it can unquestionably carry mail-bags, parcels, and packets of newspapers with great celerity; and we shall doubtless see the Pneumatic Dispatch set efficiently to work ere long.

And now we come to a very interesting and beautiful applica-

tion of the same system, which is practically in operation all day long in London—viz. pneumatic transmission as an aid to electric telegraphy. Many years ago, long before the transfer of the telegraphs to the Government, some of the companies employed Mr. Latimer Clark to lay down small tubes for the purpose on a plan developed by him. The first tube laid down was from the Electric Telegraph Company's principal station in Lothbury to the sub-stations in Cornhill and the Stock Exchange. Instead of having the trouble of conveying the telegram papers by hand, they were put into a tube and blown along in a few seconds. The plan succeeded so well that other tubes were laid down to Moorgate Street and the Corn Exchange. The papers were put into small cylinders surrounded by felt, and these cylinders acted the part of miniature carriages blown along through the tube. By little and little the system was extended, until it received a fuller development when the telegraphs were transferred to the Government, and when Mr. Siemens made some admirable additions to the mechanism then in use.

The actual working of the system at present is nearly as follows: If a message is to be sent (say) from Fleet Street to Liverpool, it is not flashed at once from the one place to the other, because the wires may not be so arranged as to permit this; the telegram paper is sent to the central office (now in Moorgate Street), whence the message is signalled by wire to Liverpool. This transmission of the telegram paper through the streets of London might be made by foot-messenger, or the message itself might be signalled along a local wire; but the pneumatic tube is found to furnish a better channel than either. Several telegram papers are coiled up, put into a cylinder, and blown along a tube which is not more than 2¼ in. in diameter. The cylinder rushes along from one end of the tube to the other, when it is taken out, and the telegram papers extracted.

Now the improvement introduced by Mr. Siemens—or, more correctly, Messrs. Siemens and Halske—consists in enabling the cylinder, or "carrier" (as it is called), to stop at one or more intermediate stations, and then resume its journey. A beautiful application of the "block" system produces this effect. Supposing the carrier travels on from end to end without stoppage, it is either driven by compressed air or drawn by rarefied air as the case may be, and its motion is gradually checked at the end by the friction of a fringe of bristles and the elasticity of an india-rubber buffer. When, however, the carrier is required to stop at an intermediate part of the tube, the *modus operandi* is exceedingly curious and ingenious. We will suppose that the carrier is to convey a roll of telegram papers from Fleet Street to Moorgate Street, and to call at St. Martin's-le-Grand to fetch some more. At the point where the tube passes through the basement of the St. Martin's-le-Grand office it is provided with two pieces of apparatus called the "transmitter" and the "receiver," each equal in internal diameter to the tube; they are of equal length and a piece is cut out of the tube equal to that length. By the action of a simple lever, either the transmitter or the receiver can be brought into a line with the tube, so as temporarily to form part of it. It is, we will suppose, made known by signal that the carrier is required to stop an instant at this intermediate station to give up some of the telegram papers and to take in others. A clerk puts the receiver (which is closed at one end) in a line with the tube; a click is presently heard, he opens the receiver, and lo! there is the little felt-covered carrier. He quickly takes out some of the papers, and puts in others; he places the carrier, not again in the receiver, but in the transmitter (which is open at both ends); he adjusts the transmitter so as to be in a line with the tube, and—heigh, presto!—the carrier is presently at the end of its journey in Moorgate Street. If St. Martin's-le-Grand has nothing to send and nothing to receive on that journey, the attendant adjusts the transmitter in the line of tube, insomuch that the carrier travels on from Fleet Street to Moorgate Street without stopping.

This simple illustration will convey some idea of the clever adaptation of means to ends in this apparatus. If it applies from Fleet Street to Moorgate Street, so will it apply from Moorgate Street to Fleet Street; if by using the transmitter only, the little carrier rushes on from terminus to terminus, so will the interposition of the receiver give it a stoppage at an intermediate station; and if the system works well between the three points which we have named, so might it be rendered applicable to other parts of the metropolis, whenever postal telegraphic service requires it. In Mr. Latimer Clark's original apparatus there was only one tube, acting alternately by suction and by compression, according as the carrier was transmitted in the one direction or the other; but in Messrs. Siemens and Halske's improved arrangement there are two tubes, side by side, which correspond to the up-line and the down-line of a railway, and of which the one works by compressed air, the other by rarefied. Each tube is provided with its receiver and transmitter at each intermediate station—equivalent, in some degree, to the two passenger-platforms at a railway station; and constant practice enables the *employés* to fill and empty, or half-fill and half-empty, the little carrier with great celerity. Only one steam-engine is employed; it is situated in the basement of the main office at Telegraph Street, Moorgate Street, and exerts a twofold action of compression and rarefaction to suit the requirements of the two tubes. Whether the operations will be transferred to the nearly-finished new postal building in St. Martin's-le-Grand we shall know ere long.

We may remark that pneumatic tubes of the simpler kind are used in connection with the telegraphic offices of some of our larger provincial towns; and that Paris, Berlin, and other foreign cities are also adopting them. Indeed, it was at Berlin that Messrs. Siemens and Halske's excellent double-tube and mid-stopping plan was first put in operation, three or four years anterior to its acceptance by the postal authorities of London. At Paris the air is compressed by water-power.

What, then, is the present state of engineering and mechanical development, so far as concerns this interesting subject of pneumatic or atmospheric transmission? We have (1) an attempt to convey passengers *outside* a tube by means of a pneumatic force developed *inside* it, with a bar or arm connecting the inner piston with the outer carriage. Its practicability has been shown; but experience hitherto has proved it to be costly to work, owing in great measure to leakage of air through the movable valve of the slit along which the bar or arm must travel. We have (2) a pneumatic tunnel large enough to contain passenger carriages, which are driven along by the pressure of air behind them being greater than that in front. It really worked on a small scale at the Crystal Palace, but its adaptability for commercial lines of railway has still to be tested. We have (3) a tube midway in size between a tunnel and a pipe, along which iron cradles or carriages can be propelled by pneumatic power at a speed of thirty miles an hour, carrying several hundred weight of mail-bags and parcels. The feasibility of the system is unquestionable; it is only waiting for the co-operation of the Pickfords, the Chaplins and Hornes, and the Postmaster-General. We have (4) a small but beautiful system of tubes, only two or three inches in diameter, along which little cylindrical carriers or travellers are blown in a few seconds, conveying telegram papers from one telegraphic station to another, preparatory to flashing the message along the wires. From human beings down to bits of paper the range is wide; and there is no reason to doubt that an interesting and valuable future is in store for this mode of transmission, although many of its developments are still in a tentative state.

It may not be uninteresting to add, that at a meeting of the New York Society of Practical Engineers in 1872, Mr. Whitney read a paper on three possible modes of driving the tram-cars in the streets of that busy city by pneumatic pressure: viz. (1) to connect the cars with an underground pneumatic tube somewhat on Pinkus's plan; (2), to elevate a large tube, worked on Rammell's plan, on columns several feet above the level of the road; and (3) to provide a tank of compressed air, on the top of each car to furnish motive power.

THE UTILIZATION OF BLAST-FURNACE SLAG.

MR. CHARLES WOOD, manager and chief engineer of the Tees Iron Works, Middlesbrough, read a very interesting paper upon the conversion of the wasteful product of blast-furnaces into a useful and very valuable material, suitable to many purposes; and the remarkable and simple way in which he has succeeded in doing this, together with the extraordinary samples he produced, has created a general interest to all blast-furnace proprietors and engineers.

Mr. Wood has two distinct processes, the first of which he calls his "slag-cooling machine," of which he produced a model. This machine is in the shape of a circular table or disc, some twelve or fourteen feet in diameter, revolving slowly and horizontally. The table or disc is about two feet broad, and is kept cool by water circulating through the plates, of which it is composed. Upon this table the slag is allowed to flow, just as it comes out of the furnaces, and spread itself upon the plates or table, forming its own thickness. The exposure in thin layers to the atmosphere very soon *sets* the liquid slag; then water is run freely upon the surface to further and quickly cool it. This makes it brittle; when, meeting with some scrapers, it breaks up into small pieces, and tumbles over into railway trucks. The material thus produced is being very largely used for making concrete for foundations, drainage works, building concrete

houses, and for road material, over which there is not a heavy traffic. Although this machine has been at work only a few months, above 8,000 tons have been made at considerable profit.

The next process is what Mr. Wood calls his "slag-sand process," by which the whole output of the slag from the furnace is at once converted into sand, and that in so remarkably simple a way that the machine employed is likely to come into general use. Mr. Wood employs a machine not unlike a Danks' furnace, containing about two feet six inches to three feet deep of water. The machine is set in motion by a small steam-engine. Attached to the revolving chamber inside are a series of floats or screens. When the machine is in motion, the water will have a tendency always to rush to the bottom, but, meeting with the floats or screens, it is always in a state of violent agitation, or rolling over. Into this water the liquid slag is allowed to run, when it is caught by the agitated water, and scattered inside the water into minute particles. The screens or floats also screen the sand from the water and elevate it to the top, whence it drops into a spout and slides into wooden railway waggons.

It will be noticed that, by the systems here described, the huge slag-balls, into which slag is now being made, are entirely done away with. The bursting, so destructive to life and property, is avoided; and it is also anticipated that a very important saving will be made in the employment of wooden railway trucks, in place of the present iron slag-bogies or waggons.

We now come to the utilization of the slag-sand.

Mr. Wood exhibited some concrete bricks, made from mixing the slag-sand with about one-tenth of quicklime. These are mixed together and passed through a die, under heavy pressure, when all that is necessary is to expose it for a fortnight or three weeks to the atmosphere, to render it fit for use. The bricks exhibited were certainly fine specimens, and if Mr. Wood can produce them equal to the samples at the price mentioned, viz., 10*s.* to 12*s.* per 1,000, they must replace millions of bricks made on the old plan of burning. There were also specimens of concrete, made out of a combination of machine-slag and slag-sand, of very great strength. In fact, the specimens exhibited had been cut through the solid concrete, without disturbing any of the edges or loosening the solid slag. Another chief source of demand is looked forward to from farmers, for manure, as the article contains about 35 per cent. of lime, and 2¼ per cent. of sulphide of calcium. This, from its cheapness, should be valuable for heavy lands, not only on account of the chemical properties, but for lightening up the soil.

A FURTHER IMPROVEMENT IN THE PRODUCTION OF CHLORINE.

THE description of Weldon's process for manufacturing chlorine contained in the fourth number of this magazine concluded by pointing out how a certain amount of chlorine is lost in the shape of chloride of calcium, and that the inventor had already taken steps for the purpose of doing away with this source of loss. For the sake of completing the notes on the production of chlorine, I give now in the following lines the substance of Mr. Weldon's new method.

The process commences with the generation of strong chlorine by the re-action upon each other of hydrochloric acid and manganite of magnesium. This operation is performed in a still, and is so managed as to yield an absolutely neutral still liquor, consisting of a mixed solution of chloride of manganese and chloride of magnesium.

This liquor is run out of the still into an iron pot, from which it is pumped up into an evaporating vessel, in which it is boiled down till it reaches a temperature somewhat above 150° C. Having attained that degree of concentration, it is run into a blind furnace, in which its evaporation is continued to dryness, and the residue piled up in heaps of thin cakes, then gently heated with access of air. The chlorine of the two chlorides is thereby driven off, partly in the free state, partly as hydrochloric acid, manganite of magnesium being at the same time reproduced.

The chlorine is partly strong, partly dilute. The proportion of the strong chlorine generated in the still to that of the weak chlorine produced in the furnace is variable.

When so working as to obtain strong chlorine and weak chlorine in about equal proportions, the quantity of liquor to be boiled down per ton of total bleaching-powder made will be about 105 cubic feet. As the proportion of the weak chlorine increases, the quantity of liquor to be boiled down diminishes; until, when the proportion of the weak chlorine to that of the strong becomes as 4 to 1, the quantity of liquor to be boiled down per ton of bleaching-powder made, is only about 40 cubic feet.

The evaporation of the liquor down to the degree of concentration at which it should enter the furnace will always be performed by the waste heat of the furnace itself.

The apparatus for the new form of process can be so fenced in that there shall be no loss of material in the solid state, as dust or otherwise: and a floor impervious to liquor, and sloping from all parts towards an iron pot, into which any liquid spilt upon it cannot but run, will preclude all risk of loss of material in the state of solution. A little fresh magnesia must be supplied from time to time, owing to the sulphuric acid in the hydrochloric acid forming sulphate of magnesium, which at suitable intervals must be dissolved out from the furnace product; but the quantity of magnesia thus converted into sulphate will be but slight, and the value of the sulphate will be greater than the cost of the magnesia required to replace it.

The magnesia may most conveniently be obtained as "Greek stone," which is a very pure magnesite, or native carbonate of magnesium.

The manganite of magnesium will usually be produced, in the first instance, by neutralizing with Greek stone an acid solution of chloride of manganese, and then treating the resulting mixed solution of chloride of manganese and chloride of magnesium as above described.

If the chlorine which leaves the furnaces as acid, and which is collected as such in a condenser, be returned to the still, the whole of the chlorine contained in the acid supplied to this process will be obtained in the free state, but partly strong and partly dilute. The strong part can be applied to the manufacture of bleaching-powder in the ordinary chambers, and the dilute part either to the manufacture of bleaching-powder in special apparatus, or to the production of either bleaching-liquor or chlorate of potash. For bleaching-powder making, however, the weak chlorine is converted into strong, and then used in the ordinary chambers.

To convert the dilute chlorine into strong chlorine, the dilute chlorine is absorbed, in a tower or towers, by milk of lime, and the product so obtained is then decomposed, in a still, by hydrochloric acid.

The product at first formed in treating dilute chlorine by milk of lime is what is known as "bleaching-liquor."

This product re-acts with hydrochloric acid, so that two equivalents of dilute chlorine are thus converted into the same quantity of strong chlorine at an expense of two equivalents of lime and two of acid.

These re-actions have been practically realized. Mr. Weldon has reason to hope that he may so advance upon them as to be able to convert dilute chlorine into strong chlorine by means of the above-stated proportions of lime and acid. On treating bleaching-liquor with more chlorine, free hypochlorous acid is formed. The product thus obtained re-acts with hydrochloric acid in such manner that two equivalents of dilute chlorine are converted into four equivalents of strong chlorine.

The absorption towers used are of lead, and they are packed with soap bricks, pigeon-hole fashion. There is a pump to them, the milk of lime requiring to be passed through them a certain number of times.

The decomposition of the product of the treatment of the dilute chlorine by milk of lime requires a second still. The acid must be put into this still first, the bleaching liquor or other product being then run in on the acid in a gentle stream.

The new form of process yields therefore the *whole* of the chlorine contained in the acid employed, except to the extent of merely mechanical loss. There is absolutely no chemical loss.

Reckoning the quantity of acid which is actually obtained in alkali works at 89 per cent. of the quantity which would be obtained if the salt used were perfectly pure and were perfectly decomposed, and the resulting acid were perfectly condensed, and making the rather excessive allowance of 12½ per cent. loss by leakage, &c., during treatment, the new method will yield a ton of bleaching-powder for every 16 cwt. of salt decomposed. This is about four times the average yield obtained by the present regenerating process.

I understand that a special plant is in course of erection at St. Helen's, in order to test the above-described re-actions on a very large scale.

THE MINERAL WEALTH OF HUNGARY.

WE propose to give in succeeding numbers an account of the mines of Hungary, their mode of working, &c. At present we are enabled to give the yield of the mines in 1871. For this we are indebted to the courtesy of Baron LEITHNER, one of the heads in the Hungarian State-Comptrolling Office, who favoured us with the subjoined table :—

Yield of the Hungarian Mines in 1871.

	Government Mines.		Private Mines.		Together.	
	Weight.[1]	Value.[1]	Weight.	Value.	Weight.	Value.
Gold, in pounds	1,131	787,995	1,653	1,153,220	2,784	1,941,215
Silver, do.	30,716	1,384,926	9,539	429,255	40,255	1,814,181
Copper, in hundredweights .	7,055	343,660	15,708	727,116	22,763	1,070,776
Lead, do. . .	34,488	438,874	4,356	59,114	38,844	497,988
Zinc, do. . .	...	...	8,262	85,927	8,262	85,927
Quicksilver do. .	...	...	323	48,677	323	48,677
Antimony(mineral), do. . .	14	187	2,519	41,707	2,533	41,894
Pig iron, do. .	294,319	1,240,995	2,078,921	6,223,555	2,373,240	7,464,550
Chrome ores, do.			10,556	5,700	10,556	5,700
Manganese, do.	540	2,159	1,638	3,242	2,178	5,401
Alum, do. . .	...	...	8,350	59,097	8,350	59,097
Alumschirt, do.	...	...	49,995	27,891	49,995	17,891
Mineral colours, do. . . .	...	...	2,800	6,170	2,800	6,170
Sulphur, do. .	...	...	10,163	13,676	10,163	13,676
Pyrites, do. .	...	...	106,873	30,983	106,873	30,983
Nickel and cobalt ores, do. .	...	...	7,896	294,374	7,896	294,374
Slate, do. . .	...	...	744,886	61,080	744,886	61,080
Naphtha, do. .	...	...	37.351	189,454	37,351	189,454
Antimony ores, do. . .	...	...	2,298	17,318	2,298	17,318
Copper sulphate, do. . . .	...	...	553	9,239	553	9,239
Coal, do. . .	1,605,783	417,509	25,178,728	5,739,632	26,784,511	6,157,141
Total value .	...	4,616,305	...	15,216,427	...	19,832,732

ON SOIL ANALYSES AND THEIR UTILITY.

(*Abstract of a Paper read at the Dubuque Meeting of the American Association Advanced Science, by* EUGENE W. HILGARD, *State Geologist of Mississippi.*

IN this paper the author reviews the objections against the utility of soil analyses, as set forth by Professor S. W. Johnson, of Yale, in an article published in the "American Journal of Science" for September, 1861. He states that, while agreeing with Professor Johnson in many of his strictures, he thought some of the objections urged inapplicable to large classes of soils in the South and West, while others were avoidable. With this view he had continued, or caused to be continued, the analytical researches already carried on for some time on the soils of the State of Mississippi. From the results obtained in the analyses of over 200 soils and subsoils, he concludes that highly important practical information can be derived from series of analyses, carried out upon a uniform plan, upon soils directly derived from uniform or uniformly variable formations, as is the case to a great extent in the South and West. The cardinal objection, that representative specimens cannot be obtained, however weighty in mountainous districts and on manured soils, becomes untenable on the prairies and even in the rolling uplands of the South, provided due care is exercised in sampling the soil—an operation second in difficulty to the analysis itself, and not to be trusted to inexperienced hands.

For the purposes of soil analysis no commercial reagents can be used, since however pure they may have been when originally prepared, the acids, ammonia, etc., become contaminated when kept in glass bottles for a length of time. All liquid reagents used must be specially prepared in small quantities as required. The solvent to be used should not go as deep as H F, or fusion with alkaline earths; nor fall so far short of what the rootlets of plants can perform in the way of solution as carbonic acid. Hydrochloric acid of uniform strength, sp. gr. 1·11 to 1·12, as obtained by steam distillation, was used in all analyses for a uniform length of time, and all operations were performed in as uniform a manner as the variety of materials permitted.

We can thus obtain *comparative* and *comparable* data, giving not the entire amounts of nutritive soil ingredients present, but the amounts respectively accessible to the action of one and the same degree of solvent action, supposing, of course, the nature of the materials to be substantially the same. We can thus compare, not any two soils from distant localities, but series of soils of essentially similar origin.

The object being, not an exhaustive determination of *all* the physical and chemical characters of the soil, but something practically analogous to the assay of ores, the chemist should on the one hand be relieved from the numerical determination of such factors as can, with sufficient correctness, be estimated comparatively, while on the other hand he should avail himself, in the practical interpretation of his results, of all that an accurate study in the field, coupled with whatever experience may have been acquired by cultivators, can afford in the way of facts and suggestions. Mere columns of figures can be of little value except as showing a great excess or scarcity of some important ingredient.

Of the latter, *potash*, *phosphoric acid*, and *lime* are those whose presence in greater or less quantity chiefly determine the chemical value and character of the soil; vegetable matter or "humus" must also be accurately determined, since upon it, as well as upon the clay present, chiefly depends the important absorptive power both for ammonia and moisture.

The results of silt-analysis being as inadequate to determine that factor as is the chemical composition, the direct determination of the absorbing power for aqueous vapour has been studied, with this result: that for the ordinary range of temperature in a saturated atmosphere, the co-efficient of absorption is sensibly constant for one and the same soil, being for—

Very sandy soils	1·5 to 2·0 per cent.
Loam soils	5·0 to 8·0 „
Heavy clay soils	12·0 to 15·0 „

These numbers representing with tolerable accuracy what is practically expressed "heaviness" and "lightness;" large amounts of humus and ferric oxide, however, interfere occasionally with the practical correctness of the estimate so formed.

The author's conclusions may be summed up thus :—

1. While the analysis of *cultivated and manured* soils can seldom give us information of much practical value, from the difficulty of obtaining representative specimens; the same is not true of the impalpable virgin soils directly derived from widespread quaternary formations, as is extensively the case in the South and West. The soils of large tracts of country can thus be classified into a few typical ones and their intermixtures.

2. Series of analyses of representative specimens, made on a uniform plan and interpreted in connection with all local circumstances, and experience had in cultivation of similar soils, can furnish information of great practical value concerning the native fertility, treatment in cultivation, and modes of improvement. They serve—

a. To *identify* as well as to *distinguish* from one another the soils of different localities, rendering the experience had with them at other points applicable in the selection and cultivation of new lands.

b. To demonstrate a great abundance or extreme deficiency of important ingredients, showing *which* of necessity will require to be added in manures, and *which* may be developed by stimulants or by the fallow.

c. Inasmuch as in soils of similar origin the decomposition of the minerals may be presumed to have advanced to a similar extent, the amounts of nutritive soil ingredients extracted therefrom by the same solvent under identical circumstances will be more or less accurately the measure of their native fertility, and of their duration in the process of exhaustive cultivation. This presumption receives strong confirmation from the results of the analyses of Mississippi soils.

d. The same analyses show that, *cæteris paribus*, the thriftiness (*i. e.* immediate producing power) is sensibly proportional to the amount of *lime* present, while (again *cæteris paribus*) the duration under exhaustive cultivation is proportionately diminished. This is what might have been anticipated, but is a highly important practical intimation.

3. Finally, the author contends that the omission of such investigations from the work of geological surveys is a grave one, not justified either by the plea of their costliness or of their want of utility, and the more to be regretted, as within a few years it may be impossible to obtain representative specimens

[1] These weights are given in Vienna pounds and hundredweights, and the values in Austrian florins.

of the best soils in their virgin condition, and because such researches require a comprehensiveness of plan not to be attained save under the shadow of a public work. The agricultural colleges will have to take up again, under great disadvantages, the work thus neglected by the State surveys. The objections that have been raised against the utility of soil analyses would, if applied to other departments of research, have debarred us from some of the most important discoveries, and are not of sufficient weight to justify us in giving up all hope of being able to understand and control the mode of action of the several kinds of soil. We assuredly can never hope to advance therein *without* analyses. He therefore calls upon the geologists of other States to rectify the omission before it is too late and a legislative *fiat* declares their labours to be "finished."

PATENT STONE-BREAKER AND ORE-CRUSHER.

ONE of the first necessities of a civilized country is that there should be good and ample means of intercommunication through it in the shape of roads. In this respect it may well be doubted whether the Stephensons who gave us railways deserve greater praise than Mr. Mac Adam, to whom, in a great measure, we are indebted for the present excellent system of roads that traverse the country. As the resources of the country became developed, the demand for more roads, as well as efficient means of repairing them, became matter of necessity; and the breaking of stones by hand labour was too slow and expensive to maintain the requisite quantity of metal. In the natural sequence of events, the necessity of providing machinery capable of preparing stone for road-making became apparent. Different schemes for machines to break or otherwise reduce stone to the requisite size and shape for road metal were devised, but such efforts were unattended with much success. The first machine that was at all successful was that patented, we believe, in the United States by Mr. Blake, consisting of a pair of iron jaws, one of which was a fixture, the other receiving a slight reciprocatory motion from an eccentric or cranked shaft. The roughly-broken stone was thrown into a hopper over the jaws; these latter were set, not with their fans parallel, but at an angle of about twenty degrees. The jaws when shut nearly touching at the bottom, and being wide apart at the top, the rough stone dropping from the hopper between the jaws was subjected to a pinch or squeeze at each revolution of the crank-shaft, the stone, being broken to a certain extent above, when the jaws opened slipped down further between them to receive another crunch on the next return of the movable jaw. Thus the operation proceeded, till finally the stone, being broken the proper size, dropped into the receiver below and was ready for use. This machine, while very efficient, was still far from being perfect. Mr. Marsden, of the Soho Foundry, Leeds, took up Mr. Blake's patents, worked, developed and improved them, and has now patents of improvements of his own, which improvements certainly have brought the machine as now made by him to a very high pitch of perfection. The characteristics of machinery of this kind, to constitute a really good machine, are that there must be no toothed gearing about it, that friction must be reduced to a minimum by a judicious arrangement of parts, and that every part must be "get-atable." As such machines are of great use, and are extensively employed in distant colonial settlements where no foundry or workshop is at hand, of course they must not be likely to break down in any part. We have carefully examined and considered Mr. Marsden's machines, and do not hesitate to express a high opinion of them. The moving jaw is actuated by an ingenious contrivance. On the back of the moving jaw is a horizontal semi-circular recess; at some distance, say about two feet from this, there is a corresponding recess in a block in the frame casting that carries the fly-wheel, its shaft, and bearings. A part of the shaft between the bearings is turned eccentrical, and a strong rod or bar, with a bearing hole in it, is fitted on this part of the shaft. The rod hangs down between the two recesses already described, and has its lower end made thicker and stronger than its body part. In this lower end are two semi-circular recesses, similar to those in the jaw and frame. The rod is such a length that when the eccentricity of the shaft has been turned so as to lower the rod to the lowest, these notches are below a straight line we may imagine to be drawn from the jaw recess to that in the frame block. Two toggles are placed with their ends in the notches, one between the jaw and the rod, the other between the rod and the frame. The jaw is kept drawn back against the rod by a spring, whose action resembles the spring which keeps the jaws of a smith's vice ever tending to open.

The action of the machine is this: when the fly-wheel and shaft are caused to rotate the eccentric part of the latter draws the rod or bar up and pushes it down. When the bar is raised it draws up the ends of the two toggles, or as they may be aptly termed, the knuckle-bars. As they are drawn up, they, of course, approach the straight horizontal line, and as the one pivoting in the notch or recess in the casting block cannot go back, the jaw is therefore forced forwards towards the fixed jaw, crushing at the same time any piece of stone resting between them both. This description, as well as the illustration, will at once make it clear that Mr. Marsden's machine complies with all the conditions we laid down above as essential for a good stone-breaking machine. In addition to these details, there is a wedge-piece introduced between the frame and the recessed block on which the knuckle-bar buts, so that wear can be compensated for and the sizes of broken stone altered as may be required, by setting this wedge piece up or down by means of a screw and lock nuts fitted for the purpose. Mr. Marsden also has added to his latest machines a means of changing the jaw faces, jaw faces made with variously shaped serrations being supplied with each machine, so that the stone can be broken to a very near approximation to different shapes. A rotating cylindrical screen, with different sections of perforations, receives the crushed stone from the jaws, and gives three sizes of stone, besides the fine dust so extensively used for garden and other walks. Mr. Marsden has various modifications of his machinery; amongst others, a machine combined with a road engine, so that it can be moved from place to place without the employment of horses. The upper illustration shows a stone-breaking machine, with rotating screen attached, for screening the broken stone to various sizes; the dotted line showing the belt which conveys motion to it from the fly wheel shaft.

The other illustration shows one of Mr. Marsden's ore-crushing machines combined with a steam-engine. In this case a great saving of room is effected, and the driving-belt is got rid of. The illustration shows the machine fitted with Mr. Marsden's patent cubing jaw, for breaking road metal to a uniform shape and gauge. The construction is simple and consists in extending the lower end, and curving the movable jaw backwards, thus making the delivery orifice a parallel channel three to four inches in length, and the corrugations match so that the projections of one enter the recesses of the other, and the arrangement leaves nothing to be desired for efficiency.

ON THE VARIOUS SYSTEMS OF COOLING THE AIR;

AND THEIR APPLICATION IN FACTORIES, PUBLIC BUILDINGS, AND PRIVATE HOUSES.

By A. Jouglet.[1]

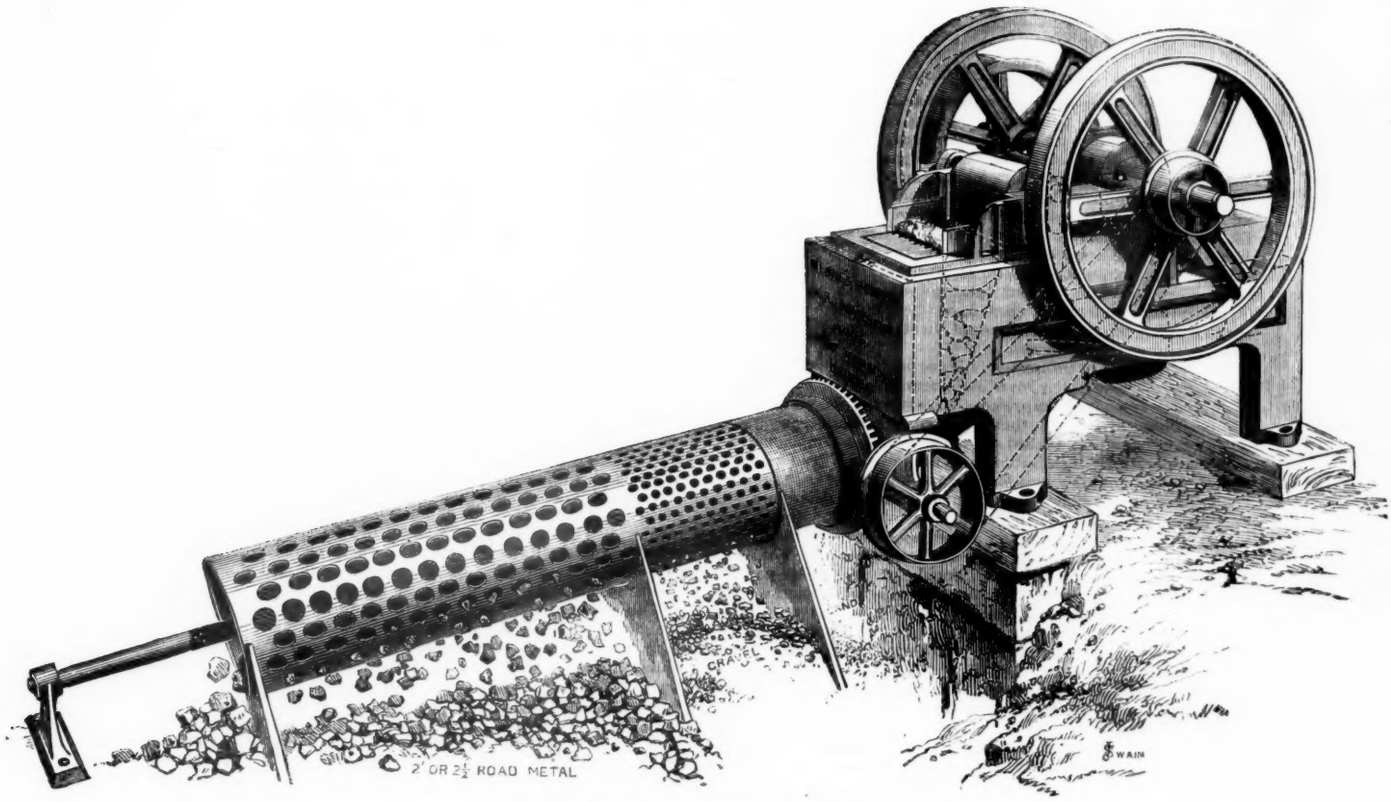
OF the many modern scientific appliances that contribute to the comfort of mankind, few perhaps are more defective than those that relate to the means of heating. In spite of all that has been said and done, we still allow thousands of cubic feet of heated air to escape from the tops of our houses, and thus waste enormous sums of money. This reckless expenditure demands our most serious consideration, especially in reference to all kinds of manufactories where the cost of fuel would be utterly ruinous but for the facilities for transport which the inventive genius of the day has so triumphantly established, that there is an easy and direct connection between the centres of production and those of consumption.

Assuming the art of economical and effective heating to be still in its infancy, that of cooling the air is barely in embryo; and, setting aside a few abortive attempts, we can scarcely find any appliances save those which, while they have gained the approval of certain experimentalists, have not yet been put to practical tests strong enough to entitle them to "letters patent of nobility."

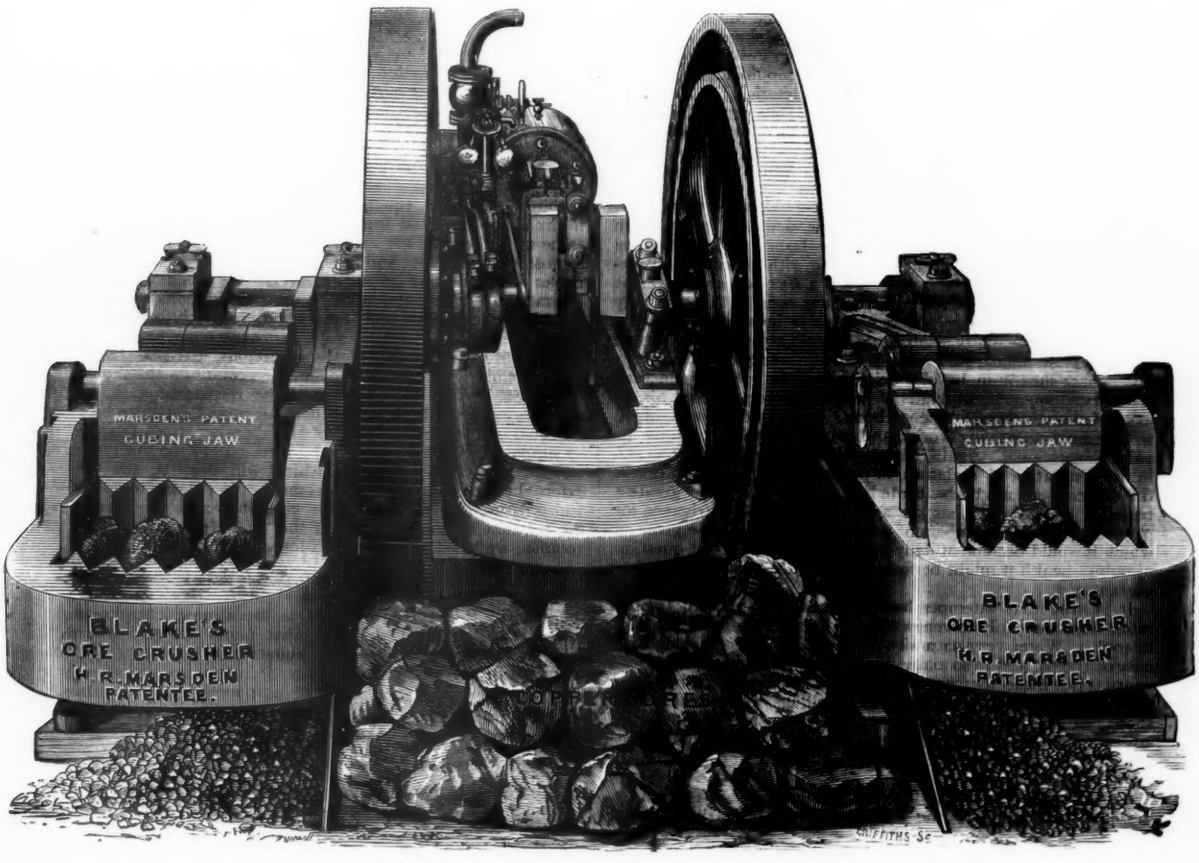
But this is no reason for despair. The solution need not be thought impossible, because it may take a long time to find it.

Indeed it may be confidently affirmed that the problem is already solved; the ingenious construction of the new contrivance which professes to settle the question inspires me with a confidence not, I hope, misplaced, seeing that the best known special treatises on this interesting subject—"How to cool the atmosphere"—fail to give even the most elementary data.

[1] From the "Moniteur Scientifique" of Dr. Quesneville, by permission of the author and editor.



STONE-BREAKER WITH SCREEN.



ORE-CRUSHER WITH PATENT CUBING JAW.

It is chiefly during the great summer heat that the need is felt; for if we could cool the summer air, we might, amongst other things, check the development of those myriads of parasites for whom heat alone is life. As soon as the first rays of spring sunshine make themselves felt, all the unseen germs which winter frosts had apparently destroyed break the fetters that had kept them bound, and new-born beings spring forth, ready armed, like so many Minervas, and begin at once their work of devastation. War, pitiless, determined, war against everything that lives and breathes—no truce, no respite; and when at last they themselves succumb to that fatal law of death to which life is inevitably condemned, they leave behind them in winter's shroud a new generation to succeed them in their evil deeds so soon as spring returns again.

Man is, directly or indirectly, in his person or in his belongings, the victim of these (often invisible) enemies, and from time immemorial every possible appliance that ingenuity could contrive has been used to conquer them. Various powerful engines of destruction have been placed at man's disposition by science, but with comparatively little success. These prolific little monsters penetrate into clothing, into food, people the very air we breathe; at the dinner-table they take a tithe of the most delicate morsels, and even follow man to the tomb, and feed upon those fragments of humanity to which no name has been given in any language. And yet, like the fly in the fable, the spider-web of death is their ultimate doom. Here an impalpable and subtle powder, projected on to the surface of the contaminated substance, will destroy a whole army of these microscopic foes; and at another time, the air itself, in violent agitation, in which they exist, will disperse the noxious germs, and with every breath bring an antidote to corruption.

It is chiefly in connection with labour of various kinds that all manner of health-giving and health-preserving measures are needed; all sorts of chemical ingredients are employed, all kinds of mechanical contrivances are resorted to for purifying the air. Take, for instance, the destruction of that terrible enemy to agriculture, the weevil. But hitherto the various methods employed have been unsuccessful. People have returned preferentially to a plan which, though anything but modern, has turned out well in most cases; the usual apparatus for ventilation, greatly improved of late years, is generally found sufficient. Chemical agencies have been almost unanimously given up, on account of the serious consequences not unfrequently attending their use.

Ventilation constitutes a question of so much importance that it has occupied the attention of many deep thinkers. Thanks to the laborious researches which this subject has led to, we are now in possession of a variety of ingenious appliances becoming more and more general in public works, factories, &c. And yet the very best means of ventilation act but very imperfectly against the miasmatic spores or sporules with which hospitals are infected; and thus some one has very wisely said that the violent rush of a mighty wind through the whole building would be infinitely more efficient.

Ventilation is but a part of the question before us, that of air-cooling, the importance of which no one denies. It has often been thought of, but hitherto it has been confined to very elementary methods which, in connection with all kinds of workshops, factories, &c., where economy is a *sine qua non*, have the unfortunate tendency of ending in ruinous results. To give only one example—a brewery. Here cold air is invaluable, and how poor and unsatisfactory a substitute for cold air is the atmosphere of the coolest cellar; and what is called a refrigerant mixture is but a sorry substitute, besides being costly and often ineffectual. At every moment in all kinds of works the help of cold air, or even of cool air, is an immense boon. In chemical works, metal works, meat-preserving works, and even in ordinary cooking, its value is very great. Again, in the preparation of beet-root sugar, in the distillation of molasses, in preparing perfumes and essential oils cold air might be turned to account with the greatest benefit if we had but a simple and inexpensive contrivance for producing it, while numbers of other instances might be given in which it would become of daily use. Even in the grand question of public health it might be found a valuable means to that important end.

It is true that attempts have been made to construct apparatus fitted not only to renew the air and to purify it, but also to cool it. Water very naturally is resorted to: it is inexpensive, easy of access, and in so many ways one of man's most useful servants. But these contrivances, not very satisfactory at best, are almost exclusively of use in private dwellings and small workshops; large factories could not turn them to account with advantage, because the enormous amount of water required for places of such a size could neither be obtained, nor, if obtained, made to work.

As far back as 1715 Doctor Desaguilliers attempted a thorough ventilation of the English Houses of Parliament all the year round, and tried a plan to cool them in summer; but it was a failure. His system was given up, and the old plan of watering only was resumed.

For a considerable time the attempt was not renewed, and yet in old times just as much as now-a-days every one must have felt that it would be both agreeable and healthy in summer-time to cool both public buildings and private houses, and it is therefore a matter of surprise that in so advanced a state of civilization as ours nothing hitherto should have been done.

Some years ago this question of ventilation received notice at the hands of the Academy. It has been often said that progress has long since been excluded from the halls of the Institute; but to refute this assertion it will only be necessary to mention what was said in open session one day by an authority of no mean order, the illustrious Velpeau. On that day the heat was suffocating, and the rays of the afternoon sun were glowing through the windows. Unable to control himself, Velpeau rose with protestations against the orb of day, and called upon the physical section of the assembly to find some method of putting an end to such a state of things. Gen. Morin, moved by the burning eloquence of his illustrious associate, rose, and stated that hitherto it had been found impossible to abate the nuisance, the difficulty being to find any current of fresh air whence might be derived the means of ventilation—the cellars of the Institute being unhealthy, and the lofts of the building at least as hot as the hall of debate;—in fact, the brave general confessed himself vanquished by the rays of the sun itself.

Although the heat has not augmented since then, and although the declaration of M. Morin was formal, the old expedients, thus condemned by the session, have nevertheless been continued. The remedies proposed may be classed under two heads: fresh air is introduced into a given space, or the conduits by which the air is to pass are kept at a low temperature.

In the first class may be found the four systems by which that very competent author, Péclet, proposes to obtain cool air. Either mechanical action is employed, and the new air is compressed, and expands at the moment of escape; or evaporation is used by passing the air over moist surfaces; or again, it is refrigerated by being circulated through pipes artificially cooled by ice, &c.; or finally, it is passed through subterranean channels, the temperature of which, nearly always invariable, is actually equal to the mean temperature at the surface. I shall examine each of these systems, which have respectively counted a certain number of supporters.

Cooling the Air by Mechanical Action.

Much was anticipated from the ingenious principle illustrated in lectures of natural science by the ordinary air match (*briquet*). It is known that when a gas is condensed it becomes heated; on the other hand, when it is expanded it cools. Let us suppose, therefore, a certain amount of air has been condensed in a receiver, and that after having left the apparatus alone for some time, the temperature of its capacity, and the gas contained within it, should be equalized with that of the surrounding air; if the air be liberated from the receiver, it will be placed in the same condition as a gas expanding to resume its normal state of atmospheric pressure, and it would follow that it would become cooler in proportion to its degree of condensation. This experiment has led several inventors to applications very elegant in a theoretical sense, and, among others, to the production of cool air.

In order to render this means efficacious, it is necessary that the sensible heat developed in the compression should be destroyed by the refrigeration of the receiver containing the compressed air, otherwise the new air would be introduced at an equal temperature to that of the exterior atmosphere. Let us suppose this condition to be fulfilled. Let t' be the temperature of the compressed air, which will thus be that of the external temperature; P', its pressure; t and P, the temperature and pressure of the expanded air when it reaches the interior; γ, the relation of the capacity of the air at pressure and mean volume; we have, according to a formula of Poisson,

$$\frac{1 + \alpha t'}{1 + \alpha t} = \left(\frac{P'}{P}\right)^{\frac{\gamma - 1}{\gamma}};$$

the quantity P is evidently equal to the atmospheric pressure; taking it as unity, and observing that t and t' never have anything except feeble values, this equation may be put into the following form:—

$$P' = \left\{ 1 + \alpha (t' - t) \right\}^{\frac{\gamma - 1}{\gamma}},$$

and replacing α and γ by their values:—

$$P = \left\{ 1 + 0{\cdot}00867\,(t' - t) \right\}^{3{\cdot}375},$$

for a lowering of temperature by $5°$, $t' - t = 5$, we deduct

$$P' = 1{\cdot}06.$$

This compression of atmosphere $\frac{6}{1000}$, or, in mercury, of 46 millimetres, at first sight appears small. At the hospital Lariboisière, in a space containing 306 beds, the new air immediately after the action of the ventilator was compressed to 28 millimetres of water, or about 2 millimetres of mercury. Now this compression, although it is excessively slight, requires, from the great quantity of air to be compressed, a 12-horse steam-engine. If the same quantity of air had to be compressed by 46 millimetres (mercury), it would require for an apparatus more useful than that of the Lariboisière Hospital a steam-engine from fifteen to eighteen times as powerful, or of 180 to 240 horse power. A power of from $\frac{1}{2}$ to $\frac{4}{5}$ of a horse-power would thus be required for each invalid. Without occupying oneself with other difficulties presented by this method, it may be seen, from this consideration alone, that it is impracticable.

In a mine in South Wales, an apparatus suggested by Mr. Piazzi Smith, despite the imperfection of the system, has met with some success. This apparatus is thus composed :—1st, of a pump for the compression of the air ; 2nd, of a refrigerator, composed of a long tube or series of tubes, within which circulates a current of water, while the compressed air passes round, the disengaged heat of which is thus absorbed ; 3rd, of a detention cylinder, where the air expands and cools to a temperature nearly proportionate to its primitive temperature: this cylinder was utilized to work the pump.

The process is not only impracticable in consequence of the considerable mechanical labour required, the refrigeration produced by expansion not being nearly as high as that indicated by the calculation, in consequence of the heat developed in the air by the jets of compressed gas and the heat furnished by the casing.

The principle of this mode of refrigeration has been elegantly carried out by a beautiful experiment of Thilorier. It has been not less happily applied to the fabrication of ice on a large scale, which proves, as a general result, that the process is capable of inducing intense cold. Ice-making machines, which have been considerably improved of late years, have maintained their reputation, and even successfully competed with nature herself. Gorrie's machine has received much notice in America ; Windhausen's machine in Germany ; in England the machines of Harrison and of Siebe ; in France the processes of M. Carré and of M. Tellier are still more remarkable, and their reputation has long since been established.[1]

Cooling the Atmosphere by Evaporation.

By this means fresh air is easily cooled, and almost without expense ; but its composition is altered by the introduction of a farther degree of humidity, which is a fatal inconvenience in many cases.

One gramme of water in evaporation absorbs or renders latent a quantity of heat enough to cool one cubic metre of air by two degrees. Let p be the weight in grammes of the vapour of water contained in a cubic metre of external air, let π represent the weight of the water introduced by evaporation ; by p_1, the weight of a cubic metre of internal air, and by y the resultant lower temperature, we obtain—

$$p + \pi = p_1,$$
$$y = 2\pi,$$

and

$$p + \frac{y}{2} = p_1.$$

The evaporation and lowering of the temperature at an end, the air is saturated. The value of p and the exterior temperature t being known, this limit may be determined by tables giving the weight of the saturated vapours at different temperatures.

To understand this method of refrigeration the limit has been calculated at different values of p, in cases where the temperature would be 30° ; at the same time the influence of vaporized water on the breathing has been ascertained ; and finally the relative humidity of the internal air, on which the cutaneous transpiration depends, has been determined by supposing that the temperature of the fresh air, on its introduction to the lungs, was raised some five degrees.

[1] A machine is at present spoken of expected to yield still more remarkable results. Its inventors are MM. Armengaud, junior, and Paul Giffard, and their calculations announce surprising effects ; the scientific public has been much excited. Will it prove a nine days' wonder? Before giving an opinion we shall, at leisure, examine the new system, which, should it justify the theories of M. Armengaud, would render especial service this year.

The results arrived at are thus tabulated :—

Weight of the Vapour of Water per cubic metre of Air.			Lowering of Temperature.	Temperature of the Air.		Relative Humidity of the Air.		Pulmonary Temperature.			
Exterior, p.	Introduced by evaporation, π.	Internal, p_1.		Newly cooled, $t - y$.	Interior, $t - y + 5°$.	Exterior.	Interior.	Exterior Air.	Interior Air.	Difference.	Relation(11)&(9)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
gr.	gr.	gr.	deg.	deg.	deg.			gr.	gr.	gr.	gr.
0	9·62	9·62	19·25	10·75	15·75	0·00	0·72	17·05	11·47	5·58	0·33
2	8·75	10·75	17·50	12·50	17·50	0·06	0·72	15·90	10·82	5·08	0·32
4	7·95	11·95	15·90	14·10	19·10	0·13	0·725	14·75	10·11	4·64	0·31
6	7·20	13·20	14·40	15·60	20·60	0·19	0·73	13·59	9·36	4·23	0·31
8	6·50	14·50	13·00	17·00	22·00	0·25	0·74	12·42	8·60	3·82	0·31
10	5·80	15·80	11·60	18·40	23·40	0·32	0·74	11·25	7·82	3·43	0·30
12	5·12	17·12	10·25	19·75	24·75	0·38	0·74	10·08	7·03	3·05	0·30
14	4·50	18·50	9·00	21·00	26·00	0·44	0·74	8·89	6·20	2·69	0·30
16	3·90	19·90	7·80	22·20	27·20	0·51	0·74	7·70	5·36	2·34	0·30
18	3·33	21·33	5·66	23·34	28·34	0·57	0·74	6·50	4·50	2·00	0·31
20	2·80	22·80	5·60	24·40	29·40	0·63	0·75	5·30	3·60	1·70	0·32

The examination of this table leads to the following consequences, which are at once evident :—1. The temperature decreases in proportion to the augmentation of humidity in the exterior atmosphere.[1] 2. The relative humidity of the interior air is almost constant and equal at 0·74, which corresponds to 87 degrees of the hair hygrometer, according to the tables of Gay Lussac, and to 82 according to those of August.[2] But it also leads to the unexpected result that the humidity introduced by the evaporation reduces pulmonary transpiration for an equal temperature of external air, no matter what its humidity, in an important proportion, sensibly constant, which, when that temperature is 30°, would be from 30 to 31 per cent., or nearly one-third. The action of interior air upon the animal economy is, in consequence of these diverse circumstances, different from that of external air.

The waste of heat increases by direct refrigeration, by contact and radiation ; on the other hand, it diminishes by double perspiration. Are these variations in an inverse sense of the principal elements of this waste, taken together, advantageous? Will the calorific equilibrium be more easy? and would it more closely approach the physical equilibrium? Let us take one of the cases in the table—that, for instance, where the moisture contained in the exterior air is 10 grammes per cubic metre. The temperature of the interior air will be lowered to 23·4°, and thus will be 6·6° less than that of the external air. The direct refrigeration of 2·5 cals. per degree is composed of two terms almost equal in intensity, contact, and radiation ; the first depends upon the temperature of the interior air, but the second specially upon that of the walls of the area, which is more elevated. Taking for the latter a mean between the temperature of the exterior and interior airs, the direct refrigeration will be greater in the interior than in the exterior by 12·5 cals. per hour.[3] Pulmonary transpiration being weaker by 3·43, the waste in this case would be diminished by 2 calorics and there would remain 10·5 cals. from which there is again to be deducted the heat corresponding to the reduction found in cutaneous transpiration. A reduction of 18 grammes an hour would compensate for these 10·5 cals., and thus, in respect of waste, the same conditions would exist as in the exterior atmosphere. Can it attain this figure? No exact experiments on the point exist.

It should be considerable, as all at once the temperature diminishes 6·6°, and the relative moisture rises from 0·32 to 0·74 ; in degrees of the hair hygrometer from 55° to 87°. The air, which is very dry, causing an abundant perspiration, becomes very moist, which only admits of very weak perspiration.

[1] Thus, in hot and moist countries, the lowering of the temperature would always be slight.

[2] The temperature of the fresh air does not rise in the interior in a mean quantity of five degrees, as supposed ; it will be greater during greater refrigeration ; but during slighter refrigeration, the relative humidity of the interior air, instead of being constant, then augments with the quantity of humidity contained in the exterior atmosphere. In summer, the humidity of the external air being always sufficiently great, the supposition which had been adopted tends rather to reduce the relative humidity of the interior air than to augment it. Lastly, an account has been taken of the individuals within the area who, by double perspiration, introduce new volumes of watery vapour into the surrounding air.

[3] In this argument it is assumed that radiation always takes place within the area, the cooled air or the exterior temperature. In the exterior, radiation, taking place half towards the sky, would be in fact greater than in the interior, even in the cooled air.

Skin perspiration depends much upon the quantity of watery vapour which the surrounding air can yet contain before arriving at a point of saturation. If it were proportionate to that quantity, it would vary, in the two cases, as 21·4 to 5·5; it would then be four times weaker in the interior air than in the exterior air. On the other hand, it is known that this perspiration very widely varies; different experimentalists have found the mean expressed in numbers from 30 grammes to 100 grammes an hour, according to circumstances. It is also known that in air at 15°, half-saturated, and therefore capable of containing 6·3 grammes of watery vapour per cubic metre more, the mean is 35 grammes per hour.

From these various considerations it may be concluded that for a like play of the organs, the reduction of skin perspiration in the interior would at most be 18 grammes. The calorific equilibrium (standard of heat) would require an additional effort from them to be established; the equally considerable reduction of pulmonary perspiration would be a further cause of trouble and discomfort. In short, the interior air, despite its being cooler, would be far more unfavourable than the exterior.[1] Such a result obtained in a particular case, is evidently capable of general application.

Cooling by steam vapour therefore acts inefficaciously upon the organism; it simply cools the area in which it acts, without refreshing the individuals contained in that area.

It will hereafter be seen, in the description of the kind of apparatus which have been tried, that the system employed at the Institute has proved the truth of this view. This system cools the fresh air by evaporation, but also by water drawn from a well at 12°; the lowering of the temperature of the interior atmosphere varies from 4° to 6°. Although the conditions of this refrigeration are more favourable than if obtained by evaporation alone, experience has shown that it produces no benefit, and even rather occasions a certain amount of discomfort.

A great number of contrivances have been put up upon this principle, but in general the experimentalists have neglected to take note of the tests to which they have been put; these would have most certainly been valuable to them. Therefore the proposed engines, with the exception of some few, are defective; and even those which have received more general approval do not comply with the economical conditions forming in this case, as in others, one of the best guarantees of success. D'Arcet has shown that to be in a proper healthy state every cubic metre of air should not contain more than 7 grammes of water, agreeing in this with the physicians who, anxious to be more precise, doubtless from self-confidence, have declared the limit to be 6·43 grammes.

At the same time we ought to be correct. It would be running into another extreme to dry the air beyond a certain point. It is necessary that there should be a certain quantity of water in the air, but not too much, as M. de Talleyrand said of zeal in reference to a certain over-vigilant functionary. In the course of his interesting researches into ventilation, General Morin was struck with the stress laid by the English experts, who have greatly occupied themselves with the question, upon the advantages in point of health, upon arrangements giving the heated or unheated air introduced into inhabited places a great amount of hygroscopicity. Thus, in summer the following plan is often adopted in London, well deserving our attention. Immediately beneath the hall to be ventilated there is another chamber, into which the outer air penetrates by several large bays; before this falls a canvas curtain to arrest the sooty particles which are floating about in the atmosphere of the great city. In front of the curtain a tap is fitted to a tube pierced with a number of capillary holes, regulating the fall of a regular water spray or dust mixing with the atmosphere imperceptibly, so that it falls to the ground without wetting it to any extent. This arrangement is intended to augment the hygroscopicity of the atmosphere, and should have upon it an influence similar to that produced by steam. The English engineers who have adopted this method explain its advantage in an original way. According to them, the vaporization of the water-spray thus traversed by the affluent air is accompanied, like the dew, the rain storms, and in accordance with the experiments of De Saussure and De Pouillet, by the development of a certain amount of electricity, which modifies the air in a salutary way by producing ozone in it. Thus, there would be a method of purifying the air, both simple and efficacious, especially in the summer. It is at present beyond doubt that the dispersion and dissolution in the air of a certain quantity of water in the form of spray, as it is used in some bath establishments, sensibly modifies the electric condition of the air; this element containing active oxygen, has in it a high degree of the property of destroying, by combustion, certain miasmata, certain bodies in a state of putrefaction—those corpuscles termed by Bergmann the filth of the atmosphere. In consequence it is only necessary to prove the existence of this beneficent gas in the atmosphere, which permeates the kind of fog formed by water in the form of dust, to conclude that the vaporization of this water, beside the accretion of hygroscopicity and the lowering of the temperature produced by it, should have an influence upon the animal economy and the cleansing of human habitations deserving of the attention of inventors.

If such be the case, there ought to be, in proper arrangements of contrivances founded upon this principle, some solution of the problem of air cooling. To this we are farther led by the observation of very palpable facts. In proportion as greater heights are attained in the atmosphere, so the presence of ozone is recognized; therefore there is no other reason to be assigned for its absence in the atmosphere, even at a very small degree of elevation, than the presence of these noxious matters so abundantly disengaged at the surface of the soil.[1] The part which ozone has to play in the great circle of the phenomena of nature is no doubt in those superior regions to cleanse and purify the atmospheric air from the deleterious compounds produced by the decomposition going on at the surface in vegetation and life, introducing themselves in a continuous manner into it, and to restore them to the condition of the fixed elements—azote, oxygen, carbonic acid, and water. Ozonometrical observations which have been made at different times and places, have constantly established a coincidence between the ozonization of the atmosphere and various epidemics. This ozonization is considerable during epidemics affecting the throat and chest, when affections of the lungs are common; and the contrary may take place, it may even arrive at a zero point during cholera, malaria, and the prevalence of paludine fevers.[2] Until now the medical profession and the sanitary commissions have not sufficiently reflected upon the results to be drawn from these well-known facts in reference to the purification of hospitals and for other physiological effects.

In my opinion it is rather to evaporation, therefore, that we should have recourse for the cooling of the atmosphere; but it is best to avoid useless and costly combinations. Much was expected of the apparatus designed by M. L. Duvoir for the ventilation of the halls of the Institute. I have already said that, despite all his experience, the intelligent constructor took a wrong course; but it must be admitted that his apparatus was not without merit. A wind shaft was placed on the roof above the hall, the conduct house containing a vertical cylinder, four metres high, full of water, similar to heating pipes; 104 equally vertical tubes were enclosed in this kind of casing of a diameter of 0·04 m., and a stream of water was kept continually flowing through these tubes. The fresh air passing by these tubes became moist and cooled. The windows being closed, the movement became evident by the chimney draught; it continued strongly even when doors and windows were opened. The fresh air was sucked down rapidly through the wind-shaft and the apparatus began to work independently of the chimney. The action was, therefore, similar to that of a chimney draught; the air being cooled instead of heated, the draught being downward instead

[1] The exterior air, just now taken at 23·4°, to rise to 30° would require per cubic metre a volume of heat represented by 1·22 × 0·24 × 6·6 = 1·93 cal. The 3·43 grammes of watery vapour to be added to the exterior air at 23·4°, to form the interior air would give in a latent condition a volume of heat equal to two calorics. The interior air also contains, although at a much lower temperature, a much more considerable volume of heat than the exterior air, which leads to the conclusion that the action of the surrounding atmosphere on the calorific equilibrium depends less upon its temperature than upon the quantity of heat contained in it. In summer the heat is far more insupportable and overwhelming when the air is very moist than in higher temperatures when it is dry.

[1] Thus may be explained the feeble transmissions above and around of the disagreeable odour perceptible in the neighbourhood of hospitals. The keen air of the mountains owes its active properties not only to its purity, but to the greater proportion of ozone which it contains. This new view is the best explanation of the healthfulness of elevated regions.

[2] During the great cholera epidemics a complete absence of ozone in the air has been ascertained. On the other hand, the Academy of Sciences granted the Bréant prize, 1859, relative to cholera, to a work on the composition of the air inspired by cholera patients, which shows that this air contains a proportion of carbonic acid much inferior to the ordinary proportion of 5 to 6 per cent., lowering to 2 and 3 per cent. in cases of recovery, and to 1·45 per cent. in fatal cases. The coincidence of these facts may be explained by the properties of ozone; it leads to the conclusion that the slower respiration is one of the causes of the disease, instead of being a simple consequence; the treatment, therefore, should point to an ozonisation of the fresh air introduced into the sick room—a process easily effected. Medical men admit that the slackening of breathing is caused by a species of paralysis of the lungs, and is only an effect of the disease; so that the treatment remains—the philosopher's stone . . . . *Adhuc sub judice lis est.*

of upwards. Having acquired a certain degree of rapidity owing to the pressure consequent upon its refrigeration, the fresh-air reached the rooms in horizontal layers; heated by the persons assembled, it rose and escaped by open windows placed at a uniform height. The apparatus of M. Duvoir thus acted well, but did not fulfil all the required conditions, owing to the causes we have already mentioned. Peclet subsequently improved upon this system by causing the air to be cooled to pass into an apparatus formed of a number of little moistened tubes—not in the interior, as in the method of M. Duvoir, but at the exterior. Each tube was surrounded by a sheet kept constantly wet, and the evaporation was stimulated by the action of a strong ventilator. It was affirmed that the necessary amount of moisture was thus introduced, but in vain—Peclet was obliged to give in, and Velpeau continued to denounce the sun.

Among apparatus of this kind M. Baumhauer's plan is particularly to be noticed. Its simplicity attracted much attention at an exhibition where it was seen in action with great success. It was composed of a cylinder into which a minutely divided current of water traversed, a current of air proceeding in the same direction and then flowing into a chimney draught in which a gas jet was burning; this cylinder was enclosed by another cylinder open at both ends, containing transverse metallic gauze, by which the cold was to pass to the air, descending between the cylinders by the effect of the lower temperature.

Cooling the Air by means of Ice.

It might be thought that this method would, at least, be preferable and likely to furnish a satisfactory result, but it is no better than the processes already mentioned.

Ice, as a refrigerant, may either be placed within or without the shafts bringing in fresh air. In the first case, generally preferred by the inventors, it melts, and afterwards evaporates in the fresh air. The cold resulting from the fusion and warming of the water produced not being more than a sixth of that due to evaporation, it therefore follows that the amount of moisture introduced into the air is about one-seventh—nearly as much as that of evaporation alone. The refrigeration obtained has the same inconveniences as before, and is equally ineffectual. When the ice surrounds the pipe without being in contact with the fresh air, it gives by fusion and the heating of the water thus produced, about 100 calorics of cold per kilogramme. In a hospital, for instance, a specific ventilation of 100 cubic metres with a temperature of 5° would require per bed and hour $100 \times 0{\cdot}24 \times 5 = 120$ calorics of cold necessary to be raised by reason of loss to 200 calorics, or 2 kilogrammes of ice. In warm countries this refrigeration would be wanted, generally speaking, at least, for five hours a day during 100 days; therefore it would require per bed and year the employment of 1,000 kilogrammes of ice, or about 1 cubic metre. Where would be the economy? In temperate climates it would always be possible to obtain that quantity of ice, despite its importance; it would always cause a high amount of expense in consequence of the ice-houses to be constructed, and even the harvesting of the ice during winter. But in hot climates—precisely where the consumption would be the greatest—it would be almost impossible to obtain it without enormous expense. In point of fact, this method of refrigeration must be considered as impracticable, while ice is not very cheap, and cold cannot be produced as inexpensively as heat.[1]

The apparatus shown in the illustration (fig. 1), and based upon this principle, may be used in some cases: its simplicity has gained it a certain degree of support. The air-conduit C C passes through a casing A B, formed of a double lining. The interior space D surrounding the air-conduit contains ice. The next space B is filled with tan, or, still better, eiderdown or wool, which acts as a non-conductor of cold. A tap R lets off the water formed by the melting of the ice into a receiver M. The air-conduit C C is fitted with mechanical fly-wings *a b*, which increase the contact of the air with the sides refrigerated by the ice. These metal fly-wings are fixed to a vertical axis, and in successive rows, but in different planes, which multiplies the surface over which the air has to pass. A mixture of marine salt and of ice is better than pure ice, should ice be dear or the casing A B small in comparison with the degree of refrigeration required. This contrivance, which manifests ingenious details of construction, may have been applied with success, but it is far from being sufficiently inexpensive. It has been calculated that the cost of cooling the wards of the Hospital Lariboisière in summer by this apparatus would equal the cost of warming them in winter, taking the minimum price of 0·05 fr. per kilogramme of ice.

Refrigerating mixtures in point of economy, so far as they have been realized, have turned out altogether illusory. True, a considerable degree of cold has been attained, but the expense is too high. An apparatus of this kind would only be accessible

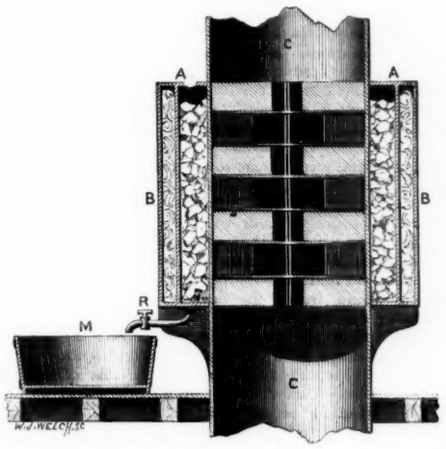


Fig. 1. Ice Refrigerator.

to amateurs who could afford to pay a fancy price, but I do not doubt that it will be adopted in some particular instances; therefore, on account of its easy management, it may take its place among instruments of medical practice. If it were possible to obtain inexpensive chemical mixtures for producing great degrees of cold, this model might be advantageously employed.

Cooling the Air by Underground Channels.

The temperature of the soil to a depth of six, ten, or twenty metres, according to its nature and the local position, is on an annual average nearly the same as the temperature of the air at the surface, but the variations to which it is subject are much less, and decrease rapidly with the depth; at three or four metres these variations are not more than two or three degrees, and the temperature may practically be regarded as constant. By causing currents of air to pass through vaults built at that depth they will be perceptibly cooled in summer if they are of any length. As such conduits are almost necessarily a part of any ventilation by injection, the cooling of air is effected by this system without any additional expense—that is to say, naturally. In two experiments made at the Necker Hospital the following results were obtained:—

Average Temperature of the Hall.	Temperature of the Fresh Air at its introduction.				Exterior Temperature in the Shade.	Difference, or average Refrigeration obtained.
	1	2	3	Average.		
22°3°	22°2°	20°62	18°8°	20°5°	25°1°	4°6°
22°4	22°6	21°2	19°6	21°1	26°0	4°9

The subterraneous channel is an aqueduct of masonry, built under the cellars at a depth of about 4 metres; the distances traversed in this conduit are on the average 15 metres for the first inlet orifice, 35 metres for the second, and 55 for the third. On the 15 first metres of the conduit, the cooling is 2·9° in the first experiment, 3·4° in the second experiment; that is to say, 3·1° on the average. On the 40 following metres the cooling is from 3·4° in the first experiment, and from 3° in the second; it is therefore evidently the same.[1]

As the quantity of air which passes through the first portion of the aqueduct, only 15 metres in length, is more considerable than that which passes through the second 40 metres in length,

[1] Of course these observations would be subject to considerable modifications should MM. Armengaud and Paul Giffard's machine produce ice as cheaply as is promised. I do not think that result, however, very likely.

[1] In consequence of the total refrigeration which increases from the first inlet to the last, the fresh cooled air is introduced into the same hall at different temperatures, an inconvenience in itself sufficiently important; to this may be added some other disadvantages.

it is certain that the refrigeration obtained in the first section arises in a very large proportion from the evaporation of the water which penetrates by filtration through the masonry itself. The refrigeration being quite as much in proportion as that produced by evaporation alone, shares, in the case of the Necker Hospital, the inconvenience existing in the latter method. By channels of a closer kind such inconveniences might be avoided, and refrigeration might be augmented by using, instead of brickwork, metallic tubes of greater conducting power.

If we now examine the refreshing action of the system, it is easy to see that it is far from being proportionate to the low temperature obtained. Supposing the conduits to be perfectly impermeable, the new air introduced always retains a relative proportion of moisture according to weight. Breathing would, therefore, remain the same, but the relative moisture would augment with the lower temperature, while perspiration would diminish, and thus would in part compensate for the direct refrigeration produced by the lower temperature. On the other hand, the conduits once established, the new air would traverse it in all seasons; the effect would be to bring up the temperature to the average level of the year, with an intensity depending upon their extent and on the varying conducting power of the sides of the conduits. From October to April, the period when the exterior temperature is less than the annual average, it would warm the new air and aid in heating the areas above; but from April to October the contrary would take place. Now, in all parts of France, the mean temperature is less than that maintained in the ventilated hospital wards; the effect, therefore, would be to extend the time of heating to a period when the exterior air is sufficiently warm as to retain, after refrigeration, the required temperature; thus, it would ever be augmenting it more or less, according to the refrigerative power. As a matter of economy, no doubt there would be regained in winter what is lost in autumn and spring. Any very considerable augmentation which would be necessary with conduits having a great refrigerative power would always be of serious inconvenience.[1] Even in the midst of summer sometimes very cold nights succeed very hot days; the cold night air, still colder in the conduits, would penetrate into the sick wards at a too low temperature, and following too quickly upon the heat of the day, might produce disastrous effects.[2] The permanent cooling of day and night produced by conduits is, therefore, noxious. This cause, combined with increase of relative moisture in the fresh air, enters greatly into the inconveniences of the summer ventilation of the Necker Hospital. Hence, instead of endeavouring to increase the cooling power of the subterranean conduits by injection of air it would be better to reduce them in size, and to render them perfectly water-tight.

On several occasions attempts have been made to refresh the air by these means. At the Conservatoire des Arts et Métiers fresh air had been pumped from cellars. At Paris it has been proposed to obtain fresh air from the catacombs; it is true that the temperature of these places is about 11 degrees, but such air is unhealthy, especially on account of the exhalations from the drains and the cemeteries. Besides, such a system is very complicated.

General Morin has sought to show that it was impossible to depend on any one of these methods. He experimented upon that system by which it was attempted to cool the air just obtained by the ventilator, by passing it before its introduction through a water-spray. According to M. Morin, this process only produced a lowering of the temperature of some two degrees; it would thus require the use of a very considerable volume of water and a strong motive power to produce an effect most disproportionate to the cost, if specially set up for the purpose. General Morin has also condemned the process of passing the air by the sides of metal casings containing cold water. We have admitted that this process is very difficult of application. "It is efficacious," says General Morin, "but it requires the use of very extensive surfaces in proportion to the volume of the air cooled, even when the water has previously been cooled by a refrigerating compound, the weight of which in kilogrammes would be almost equal to the number of cubic metres of air to be cooled."

Such are the difficulties which have led General Morin to propose other methods more immediately imitating the ordinary phenomena of nature, and appearing to him the only methods applicable in all cases, and sufficient for ordinary requirements.

These methods belong to the second class, of which I have spoken; they are founded upon direct refrigeration. All previous heating of the air passages is here objected to, as well as of the chambers into which the air is admitted.

One of these methods is to assure a constant draught of air by numerous proportioned air-holes, thus requiring, according to General Morin, who has taken this view into favour, only easy conditions everywhere applicable and very inexpensive. The outlets should be calculated to admit of an entire replacement of the air every half-hour, and the usual swiftness of the issue may be calculated at 0·40 m. to 0·50 m. per second. The outlets should be iron-plated outside, so that the action of the sun by heating the plates should increase the draught; their height should be some three metres, and more above the roofs. The inlets should be as numerous as possible, and open, if possible, on that side of the orifice not exposed to the rays of the sun; their dimensions should be determined by the condition that air should not pass through them at a greater speed than 0·30 m. to 0·50 m. per second, and that the volume of air introduced should suffice to renew the atmosphere of the area at least every half-hour. Windows exposed to the rays of the sun should be furnished with closed blinds, or shielded by external blinds, unless they should happen to be in the form of a verandah, in which case they should be well watered and covered with linen cloth. For factories and other places lighted with gas, care should be taken to assure the escape of the products of combustion, either directly to the outside, or, when possible, by chimney ventilators, the action of which they would increase. These chimneys should be provided with registers to moderate their action according to the weather and the seasons.

Such are the terms in which General Morin describes his plan—really only a partial solution of the question, and, I will even venture to say, a very incomplete one.

Nature, which often places the remedy close to the evil, in some cases inexpensively furnishes the means to cool the air. In ascending to the attics of dwelling-houses, the immoderate heat developed by the sun's rays is very perceptible, especially in cases where the roofs are covered with metallic substances. Now, the question is how to turn this heat to account for the introduction of pure air. In 1800 Dr. Anderson suggested the application of such a system. The mode of doing so is very simple. A ventilating chimney (see fig. 2) is placed on

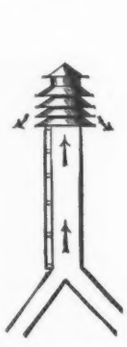


Fig. 2. CHIMNEY.

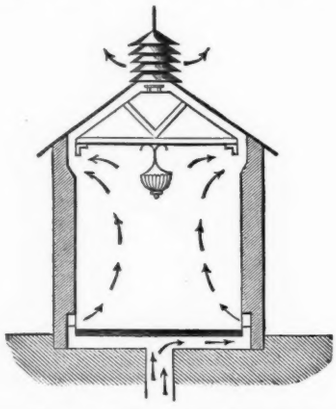


Fig. 3. VENTILATING CHIMNEY.

the top of the building, to which abut side props, forming a double ceiling, and having communication by vents in the cornices. The fresh air coming from the cellars enters the room by hollow pillars or vertical props, according to circumstances; and at night, the natural heat of the sun not being available, artificial heat is employed. For museums and meeting-halls, Anderson proposed numerous chimneys having pierced glass frames on the southern side (fig. 3), and closed on the three other sides; the sun striking on the panes of glass would produce a draught commensurate with the intensity of the heat.

M. Regnault proposed a similar plan for the buildings of the Exhibition of 1855; he offered ingenious combinations, of which no notice was taken. There is no reason to be surprised; the matter happened in France, and France is the country of doubt and incredulity.

In Switzerland a system has been originated having great analogy with the proposals of M. Regnault. The inventor, M. Pradez, started from a very simple point of view. The negro, who

[1] At Paris, for instance, where the mean temperature is 11 degrees, heating would have to commence fifteen days earlier and end fifteen days later. Its actual duration, some seven months, would therefore be prolonged to eight.

[2] Every kind of ventilation presents this difficulty; but it is much increased when the fresh air grows considerably colder in the subterranean regions by night; it would be necessary to use higher degrees of heat in cold summer nights.

is born in the torrid zone, has been endowed by nature with a woolly head of hair, which the sun strikes without reaching the cranium itself. As soon as the air contained in the hair is heated to a greater degree than that of the surrounding air, ventilation takes place of itself in a regular and natural manner; the negro, whose head is bare, is better protected against the rays of the sun than the European with his hat. M. Pradez has applied this observation to railway stations. By his plan, it is sufficient to protect the metallic roofs against the sun in the same manner that flowers are protected in hothouses against frost, viz., by straw bands of sufficient length and strength. This is a very ingenious method, but, like all those we have named, it can only be applied in a minority of instances.

Another method, recommended especially by General Morin, is the imitation of the effect of rain; it is susceptible of being used almost directly to most edifices and dwellings. According to M. Morin, it would not require more than a cubic metre and a-half of water per hour to moisten 100 square metres of roofing, and to shelter them from the heat produced by solar radiation. Applied in the morning and during the heat of the day, it not only obviates the heating of roofs, but as long as the temperature of the water is less than that of the air it can maintain the interior walls at a temperature far inferior to the latter, and cools the air ascending to the attics. This method of watering being accidental, and only being required during some sixty days of the year, it is easy to see that even for a station as large as that of Orleans, which is 138 metres by 28, the annual cost would be no more than 1,000 francs, or forty pounds sterling. It must be admitted, however, that this method, used in some places, is not to be recommended. It is not only under the immediate roofs that the heat is intolerable during summer, the effects are visible on every floor; and if the heat be more sensibly felt under the roofage itself, it is quite clear that during the hot season there is a necessity for tempering the atmosphere throughout the house. Now, I much question whether the continual pouring of water on the roof of a house would have much effect upon the inhabitants of the first or ground floors. This refrigeration, on the contrary, would rather tend to arrest the course of the air from the attics, and would thus make atmospheric circulation less rapid. The constant dilapidation of the roof would also follow from a constant pouring of water upon it; it is hardly necessary to urge more by way of demonstration. The Roman architects employed this method in the amphitheatres; one vast cloth spread above the heads of the spectators was continually played upon by water jets. In our days some inventors have tried similar combinations; in some places blinds may be found on which a minute stream of water is playing. To these contrivances the strange name of hydraulic blinds has been given.

As pure air was sought to be drawn from subterranean localities, so also it was attempted to bring it from the skies; it has been taken from great elevations by means of high chimneys and steeples. At the Lariboisière Hospital, the draught of air on the top of the tower is regulated by a mechanical ventilator fixed on the building. At Guy's Hospital, London, a similar method is used. The air drawn from the summit of the tower, by means of a chimney placed at its base, traverses the wards of the hospital, and is driven out by a second chimney situated in the vaults, producing a constant passage of air in every apartment. However efficacious this method, it must be admitted that in summer the elevated strata of the atmosphere do not possess a temperature materially different from the lower air sufficient to mark the system as a success.

It is evident that these various methods of cooling the air may sometimes be simultaneously employed. This is what has been done in Russia by the engineer, M. de Derschau, the apparatus constructed by him offering an ingenious application of the two processes previously described. It is true that this application is expensive; but it was a saloon carriage for an empress, and in such a case expense is no object. I shall describe it, as there being still emperors and empresses to use it, such description will not be out of place.

The system of M. de Derschau consists, in the first place, of double roofs, painted white, with apertures between to counteract the rays of the sun. To cool the temperature of the carriages, M. de Derschau has placed in them two cooling apparatuses, consisting of two hollow columns in carved oak—M. Regnault's system. Each column communicates with the outer air by means of an air inlet in the form of a funnel placed beneath the carriage in the direction of the motion of the train, closed with very fine double gauze. As long as the exterior temperature does not exceed 22°C., the air entering at the lower end of the column and emerging by orifices made under the capital, this apparatus offers a very useful means of ventilation by giving every hour more than three volumes of fresh air in an imperceptible manner. To render the advent of fresh air insensible, the capital is ornamented with hanging plumes. When the external heat is augmented, a metallic cylinder, of less diameter than the column, is fixed inside, and charged with ice and crystallized chloride of calcium, in the proportion of 4 and 3 parts. In this case, all the windows being closed, it is possible to lower the temperature six degrees below that of the exterior air. It is possible even to attain a greater degree of coolness by modifying the composition of the refrigerating mixture and increasing the size of the apparatus; but then the moisture of the air is so much increased in the carriage as to render it disagreeable, especially when there is too great a difference between the interior and exterior temperature.

This new method of cooling railway carriages is certainly a step in advance, and I regard it as very much superior to all the methods hitherto proposed for the purpose; but, as M. de Derschau himself very judiciously says, it is not to be supposed that it could be applied on a grand scale, in consequence of the expense, the difficulties attendant upon its regulation, and the constant loss of material. It is a luxury for kings alone. They have done better than this, however, in America. In that country the railway cars are heated in winter, a fact unknown in France; and more than that, they are ventilated in summer; for this purpose they are hermetically closed, there is only an opening left in the floor, beneath which is a tank of iced water; at the axles of the wheels a gearing is fixed, which puts a ventilator in motion; the air, passing through a grating, is cooled and purified by the dust being laid. As a refinement upon comfort, this ventilation takes place in winter also, the water then being heated.

During the last ten years new investigations have been made in the subject, not only in France, but in other countries, and especially in America, where contrivances are continually to be met with, the details of which would be worthy of notice. In France favourable mention has been made of the apparatus of M. Piarron de Mondésir. In 1870 this gentleman communicated to the Academy of Sciences a note in which he describes the system for which he had previously taken out a patent for fifteen years. It is similar to that which he applied with some degree of success in the Champs de Mars in 1867. "At the Exposition of 1867," says the author, "during the days of extreme heat, the new air propelled by compressed jets of water through the wooden gratings in the central part of the Palace on the Champ de Mars, arrived clear of dust, and remarkably cooler. This method of preparing fresh air consists of the addition of a minute jet of water in the middle of the compressed motive air jet. The water is literally pulverized by the compressed air, the dust carried off falls into the trough which receives the overplus of the water jet, and in consequence of the intimate mixture of the pulverized water and the air, the latter is at once brought to a temperature as low as the outside air is high." M. de Mondésir goes farther, and proposes to apply his system to hospitals. "In that which concerns the vitiated air of hospitals," he observes, "a jet of compressed air being placed at the base of each ventilating chimney, it would be sufficient to replace the water by a disinfecting fluid in order to obtain a mechanical mixture similar to that just described for fresh air. The organic particles of the vitiated air would probably be precipitated in like manner to the air dust, and received in the trough. The intimate mixture of this disinfecting vapour, and the vitiated air carried off by the outlet chimney, would also guarantee a complete purification of that air.[1]

The arrangements of M. Piarron de Mondésir have been applied at the establishment of La Belle Jardinière; they have cost much money, and yield very mediocre results, as it is easy to perceive by a visit to that establishment on a hot day in June. Other applications have been tried in factories. His apparatus has not only been tested in domestic economy, but in brewing. The brewers, however, were no more satisfied than the authorities of La Belle Jardinière; the director of the Theatre Lyrique appeared better pleased with it; but M. Piarron de Mondésir, with all his cooled air, could not save the theatre from the catastrophe which has rendered it a heap of ruins.

It must be admitted, however, that the system of M. Piarron de Mondésir was ingeniously conceived. It has done good service, and will do so again; hence I am not surprised that it had the honour to figure in the Transactions of the Academy, and that it has produced to the inventor and patentees legitimate recognition. Furthermore, M. Piarron de Mondésir has the further merit of being the first to think of creating apparatus for various practical branches of manufacture; if he has not quite solved the question, at least he has advanced its solution in a great degree.

At about the same time M. Carré busied himself in applying the system he has so happily employed for the manufacture of artificial ice. Still more fortunate than M. Carré, a gentleman

[1] Note on "Ventilation by compressed air; purification and cooling of new air; disinfection of the air," "Comptes-Rendus de l'Académie des Sciences," Session of the 4th April, 1870.

who closely studied the subject, M. Tellier, the ingenious refrigerator, discovered, by combining the known laws of nature with the properties of ammonia, a plan, the advantages of which were soon recognised.

It is known that *in vacuo* liquids instantaneously give off vapours, reaching their maximum of tension at once. On the other hand, it is also known that if two intercommunicating receivers are maintained at unequal temperatures, there is always vaporization going on in the colder receiver. The following application is the result of a combination of these two laws with the properties of ammonia. The apparatus represented in fig. 4 is intended to produce a cooling of the air. It is composed of a chimney A A, the height of which is variable, at the top of that chimney is vertically placed the tubular generator B, containing a solution of liquefied ammonia to the line *b b*. This perfectly isolated receiver is in direct communication with the serpentine condenser E by the two pipes F and G—the receiver E is also perfectly isolated. Around the serpentine circulates well water. No matter what the temperature may be outside the apparatus,

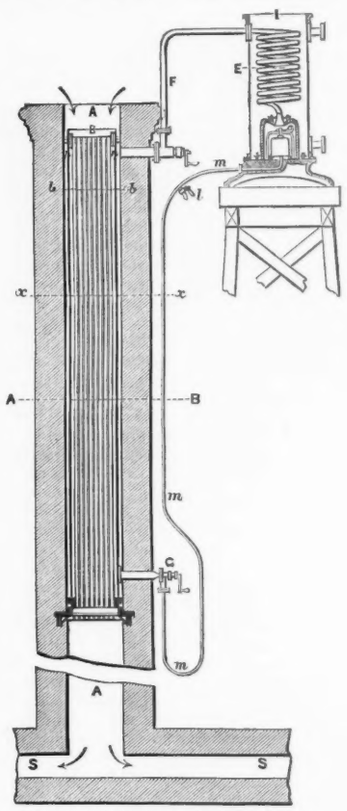


Fig. 4. AMMONIA REFRIGERATOR.

it is evident that the interior pressure would be superior to that of the atmosphere ; the ammonia would therefore vaporize as well in the chamber *b b n n* as in the tube *m m m*. The gaseous current being thus formed, sweeping through the interior atmosphere of the tubes and serpentines, would carry before it the air which would be expelled by turning the tap *l*. By means of an india-rubber pipe placed upon the nozzle of this tap, this current would be received in a vase containing water. The air would escape, the ammonia would remain in the water, and when the absorption was complete, and no more bubbles were formed on the surface, it would be seen that all the air had escaped ; it would then be necessary to close the tap *l*. This being done, nothing would remain in the interior but the liquefied ammonia, the vapour of which, immediately attaining the maximum of tension, would at once fill the space left empty by the expelled air. If then by any accident the temperature of the generator B became higher than that of the condenser E, vapour would at once be formed in the receiver B, which would proceed to condensation in the receiver E, until the balance of temperature was restored. This action would be all the more rapid in proportion to the rapidity with which the vapour is induced in the vacuum ; and would be also in proportion to the condensation. Thence there would be a relation between the force of the condensing action in E, the promptitude of vaporization in B, and the energy of refrigeration of the body passing in the tubes *x x* and round the casing B. Now, this body is no other than the atmospheric air freely entering at the orifice A and penetrating the tubes *x x*, drawn by the increase of density communicated to it by refrigeration, and causing it to descend the chimney. If the surfaces are sufficient the temperature will remain equal between B and E ; therefore if the water which reaches the condenser is at 9° or 10°, the air which emerges at the lower part will have that temperature ; descending the chimney A A, this air passes by the conduits S S to freely distribute itself in the localities where it is necessary to produce a cooler atmosphere.

Unquestionably this arrangement, susceptible of modifications according to circumstances, is ingeniously conceived ; according to the inventor it has the merit of cheapness and utility. But it appears somewhat complicated, and this complication materially limits its application in many instances, especially as we have at the present time an engine which, if not constructed in so original a manner as the engine of M. Tellier, offers guarantees of success of a similarly weighty kind, and is more economical. The employment of ammonia in itself is an obstacle, among others, to the application of the apparatus. In industrial matters it is constantly desired to find, not elegant combinations, but those which are simple and practical. In some breweries and chocolate factories, this apparatus might be of signal use ; but, despite its utility, despite the incontestable claims of the inventor, it cannot be looked upon as a final solution of the question. To this apparatus I prefer another application of the properties of ammonia, by which M. Tellier has produced an extremely simple and useful method of emptying cesspools.

That which is sought is an apparatus, not only to cool the air in apartments, but especially to produce the same effect in certain of the branches of industry we have already mentioned. And yet even in domestic economy no satisfactory result has yet been obtained, as we have already shown.

Apparently this problem of heating houses during winter, and cooling them in summer is one of great simplicity, and appears so to the veriest tyro, and yet we do not fail to suffocate in summer and freeze in winter, in Paris, as elsewhere, despite of chimneys and warming apparatus, despite of closed windows and watered streets. When it is considered what the sufferings of the public are in assembly-rooms, theatres, exhibitions, museums, clubs, cafés, and even small rooms where any number of persons meet together, where hot and injurious vapours are created, we cannot but loudly call upon science to interfere in this great public sanitary question. Therefore the apparatus which would simply fulfil the required conditions would meet with success, if not in France, where very slight attention is paid to individual comfort, yet certainly in other countries where so many sacrifices are made to allow that degree of comfort so dear to the island inhabitants beyond the Channel, and which advanced nations have a right to respect.

This very interesting question seems to me to have been answered by a system founded upon well-known principles, and which has the merit of being universally applicable : industrial enterprise is an especial gainer, and will take deep interest in the importance of the results attained. This new method is allied to the first class of methods of which we have spoken. In this both water and a ventilator are again employed, but the dispositions of the system are completely different ; to some degree they remind us of the tubes in the apparatus of M. L. Duvoir. But have not all inventions, if looked closely into, something in common ? But if the two methods of application are carefully considered, it will be seen that there is a wide difference between them. M. Duvoir cooled the air by pulverizing the water ; MM. Nézeraux and Garlandat lay no claim to this pulverization of water ; they content themselves with filtering the air, if I may use the term, through water, and thus purifying and cooling it. Furthermore, in this new system the simplicity is incontestable, the utility is evident, and the economy is certain.

The original idea is due to M. Nézeraux, and the apparatus constructed in consequence was jointly perfected by MM. Nézeraux and Garlandat with signal success. The principle already existed in an apparatus previously designed by M. Nézeraux, and used in the workshops of a well-known constructor, M. Flaud. This apparatus, upon which has been bestowed the name of hydro-atmospheric condenser, is composed of two distinct parts, the condenser A properly so called, and the refrigerator B ;—the condenser of a series of tubes assembled between two plates forming part of a cylindrical casing hermetically closed, of a pump which serves at once for circulation and evacuation, and of a chimney K, by which the air, saturated with water, escapes. (fig. 5). The refrigerator is formed of a metal plate pierced with

holes of small diameter, and of a ventilator the current of which passes through the orifice I. The steam escaping from the cylinder penetrates to C, disperses through the space between the tubes, condenses itself by contact and produces a vacuum. The water which has just condensed the steam passes above the perforated plate B, upon which a current of air is continually in action from above and beneath, which divides the water and instantly cools it; it falls into the tank D, whence it is pumped by means of the tube M and brought back by E; thence it passes uniformly through all the tubes over the whole extent of the refrigerating surface by means of little fluted plugs or similar contrivances at the top of each tube. The conducted steam is drawn off at the base of the apparatus at H by means of a pump, to be restored to the feeding tank. Applied to ordinary condensers the refrigerator effects a considerable economy of water, and produces other advantages which it is unnecessary to mention here, not concerning the subject under consideration.

If the steam-boiler and steam be suppressed in this apparatus,

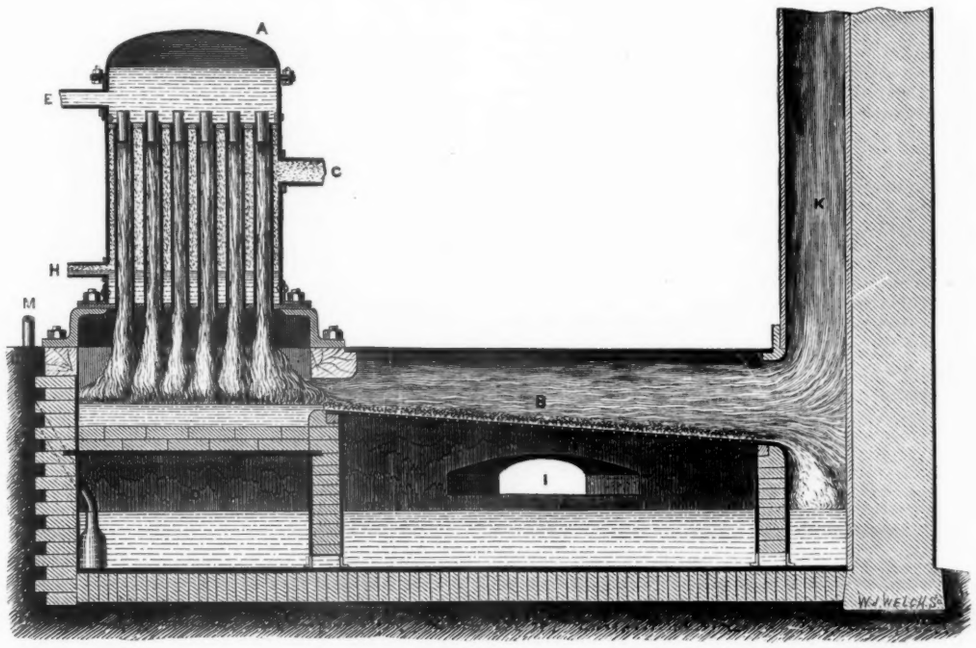


Fig. 5. AIR REFRIGERATOR.

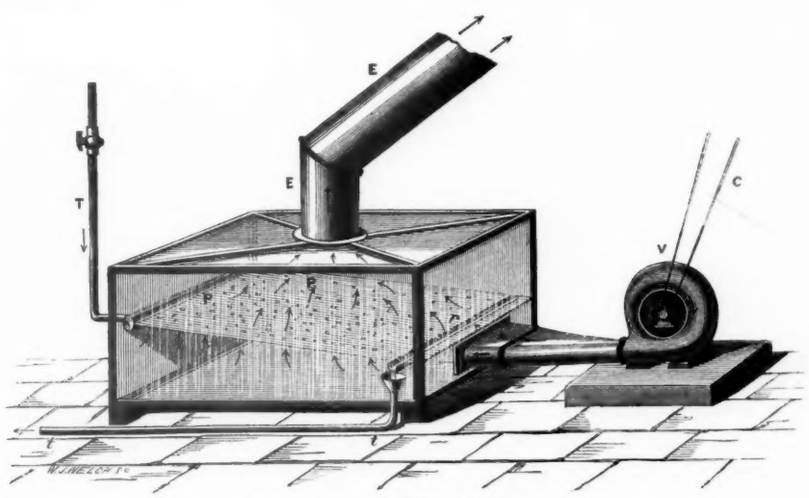


Fig. 6. VENTILATING APPARATUS.

and the perforated metallic plate and ventilator be only retained, we obtain another apparatus, of which I shall give a description, specifying some of its uses (fig. 6).

Through the perforated plate, either of metal or some other material, P, from beneath to above the ventilator V, set in motion by the hand, or, in the case of a more considerable application, by some mechanical motor, keeps up a current of air which passes through the numerous holes of the plate. Above this plate cold water is introduced by the pipe T, furnished with a regulating tap; the water passes into a water-pipe, whence it issues in a uniform manner over the plate, which is slanted in such a manner that the thickness of water shall not exceed certain limits; in some cases ice or chemical solutions, as those of phenic acid, may be substituted, according to the application of the apparatus. The pressure exercised by the propelled air suffices to maintain the water on the surface of the plate, and prevents it passing to the lower part. The water flows slowly on to the plate, and after having passed over and given its coolness to the air which penetrates it, finally reaches the other pipe, by which it runs to the issue at *t;* in most cases this water is again

useful for other purposes. As to the cooled air, it penetrates into the upper part of the apparatus, escaping by the tube E, and reaches the places where it is wanted.

Such is the apparatus which has been called the *refraîchisseur* or refrigerator; it is very simple in its construction, as may be seen at a glance, nor is its action less remarkable. By this new method we have no operation of the pulverizing of water; a system of a complex and often unhealthy nature, particularly if in the hands of ignorant and negligent persons. Here the air which emerges from the apparatus carries with it an amount of water much lower when expressed in numbers than those with which insalubrity is held to begin; it is, in fact, purified air, rendered healthful, fresh, and as it should be. Taking it as it escapes from the apparatus, it would be found by chemical analysis to contain the exact proportion of water necessary to endow it with every hygienic quality. The inexpensiveness of the apparatus is at once apparent, but as the scale on which it might be wanted would vary according to local requirements, the cost of erection would of course also vary especially between certain limits.

The utility of the apparatus consists in the perforated plate, which presents a large plane of action. It is to be remarked that the same air can be re-introduced into the apartment where its beneficent effects are required. In fact, if the fresh air introduced by the apparatus seizes upon the noxious gas, it will be definitively expelled; on the other hand, if it have only conquered some degrees of heat, it can be again taken up by the ventilator and again conducted to the perforated plate, there to leave in the water the hurtful particles, and again recommence its course. Well or spring-water will supply the liquid at the required temperature; the temperature, in fact, can be lowered to about 12° centigrade; if a lower temperature is required, this can be obtained by placing ice or frigorific materials on the perforated plate. In all places coolness exists under the surface, no matter what the temperature of the climate; and it is sufficient to simply extract this cold naturally represented by water obtained from a certain depth, to produce by means of MM. Nézeraux and Garlandat's apparatus fresh and even cold air. It is not uninteresting to remark that the machine to be set to work requires a very moderate force. Such is the power developed by the exercise of very slight force, that several thousand cubic metres of air per hour may be cooled; and for this purpose a plate measuring one square metre is sufficient.

I shall mention some immediate applications of the apparatus of MM. Nézeraux and Garlandat both in domestic economy and manufactures.

In private dwellings, where it is cold in winter and warm in summer, it will fulfil during great heats the same duties that the stove fulfils during the cold days of winter. The one warms the air, the other cools it. When combined, they complete in domestic life the series of modern contrivances creating comfort around us. I do not fear to say that at a future time fresh air will be distributed just as hot air, light, and other things now are. By the aid of a tap, coolness will suddenly be spread throughout a room where the temperature is insupportable. In our great cities we habitually seek, during hot evenings, for cool air under the shadow of trees; but the air is calm and a noxious dust is suspended in the atmosphere; in vain do we ask from a faint breeze the much-desired coolness. Would it not be possible to construct concert-halls in which one might, as it were, actually take fresh-air baths? If such an application have nothing very novel about it, at least the summer heats would offer occasion for it.

American newspapers some years since mentioned a curious system already realizing this idea. One summer evening an ingenious and wealthy individual was receiving his friends; the heat was insupportable, the house was stuffy and unbearable; the pretty American ladies who adorned the reception-room had almost even come to curse those light gauze dresses beneath which, in America as in Europe, are hidden the treasures of loveliness. Suddenly, O miracle! to these horrid effluvia of heat there succeeded a beneficent breeze which wafted an odour of jessamine; to this perfume was joined a rosy freshness, a delicious balm circulated everywhere, filling the apartments. For some days after there was nothing talked of in New York except the idea of this rich Yankee, and the system came into fashion; unfortunately the complicated nature of the apparatus rendered it inaccessible except to the privileged of fortune. Now, if some architect succeeded in fixing the apparatus of MM. Nézeraux and Garlandat skilfully, it is not to be doubted that in Paris, that city of the Sybarites, perfumed saloons, whither the crowds would eagerly press, might be created. I can see the effect: with one turn of the crank, behold, the essence of roses; another turn of the ventilator, and another perfume takes its place.

If we enter our palaces and inquire what provision has been made in cases of great assemblies, we are shown the windows, nothing more and nothing else. On the other hand, let us see what the sanitary engineers of England are doing. In reception-rooms the problem is delicate; it is necessary to maintain the rooms at an equal and supportable temperature, and to guard against the perfidious draughts so fatal to ladies in ball-dresses; for, according to the Chinese proverb, you should shun the wind of a narrow passage, it is more treacherous than the point of an arrow. It is necessary to provide against the difference in sensibility in different persons—some persons being able to endure great heat with impunity, and others finding their lungs congested very soon; in fact, it is necessary to feed the room with fresh air without its being perceptible to the occupants.

One of the most widely-spread errors on the subject is the confidence felt in the mere renewal of the air in refreshing the apartments. It is not sufficient to carry off the odours; that is not supplying what is required, viz., the vivifying properties of fresh air itself. The counsel of D'Arcet, the father of ventilation, has been misinterpreted; usually all that had been thought necessary to purify and refresh the rooms was to open the windows, and when the heat was intolerable, without any regard to the possible generation of chest complaints or rheumatism in the persons seated by the windows. This is not the solution of the problem, but an attempt to construe the task backwards. In the depth of the factories, far from sumptuous saloons, exists a population of labourers whose daily, nightly, hourly sufferings are worthy of compassion. But over that matter whence they obtain those marvellous transformations which, in a moment, make of a piece of iron a nail, an axe, or a sword, or of a little silk an elegant robe, a piece of lace, or a ribbon, they undergo that terrible sentence which was once pronounced upon humanity—"Thou shalt earn thy bread by the sweat of thy brow." Enter the kitchen in the midst of burning stoves of which Brillat Savarin only knew the succulent wonders; descend to the underground regions of the restaurant; an intense heat seizes you in the throat and temples, and you seem to be falling into a swoon; open the doors of the furnace devouring tons of coal at a time, and contemplate those haggard, suffering, breathless beings, whose feverish limbs are watered by perpetual perspiration; contemplate all this, and you will perceive that there is no reason so loudly to condemn the abuse of alcoholic beverages, the only resources of these disinherited of comfort from the fever which racks their wasted limbs.

It is therefore in great factories that the apparatus of MM. Nézeraux and Garlandat is specially destined to have a humanitarian utility. As in dwelling-houses, workshops established under the roofs are especially liable to the overheating of the air, and for this reason only are very unhealthy. If open windows and skylights to a certain extent modify these inconveniences, at the same time they frequently aggravate the consequences by the air-draughts admitted by these often insufficiently supplied apertures. By day they are not sufficient to moderate the temperature, and it is not unusual in garret workshops to see the thermometer marking 40° to 45° C., while the external temperature in the shade is not more than 30° to 32° C. The railway stations, notwithstanding the permanent openings in the roof-ledges and the extremities, are, during summer, real stoves, where it is extremely disagreeable, and even dangerous, to remain for a continued period.

The same observations apply to hospitals, public schools, &c. In reference to hospitals it would be easy to enlarge as to the advantage of this system, especially in summer time, when pestilential diseases are so frequent and so dangerous.

The hygiene of the question may be expressed in a sentence—as is the air so is the blood. Now the air is like Cæsar's wife, it should be above suspicion. It is a study of the composition of that important element, so different according to locality and temperature, shows the necessity of modifying it according to exigences in inhabited places. Next to that hereditary law which transmits to us phthisis, madness, scrofula, &c.—next to the excesses or vices of our alimentation—the air which surrounds us is the reservoir whence we draw all our diseases. It has been justly said by one authority that "our own breath is our greatest enemy"—and not less happily by another, "*Plus occidit aër quam ferrum.*" These diseases, for the most part invisible and intangible, are floating around us; they exist in the form of germs, only requiring a favourable soil to develope themselves. If in epidemic diseases we have a sufficient power of re-action, if we can avoid the causes of moral and physical weakness, we shall escape the evil; if, on the contrary, our age, our constitutions, our habits of life, make our organs into a soil propitious to pathological vegetation, the disease will take root in us, and we shall see small-pox, typhus, hospital fever, puerperal and intermittent fevers among us—or, in other places, the plague and a host of affections the causes of which are unknown,

upon which microscopical study has thrown the light of a new day. The doctor is the horticulturist who is charged with the duty of eradicating from our organs these evil weeds before they have taken root at our expense. It may thus be said that a hospital is nothing but a great field representing the whole flora of our diseases, a kind of ocean in which float fevers, small-pox, typhus, and the whole sad procession of contagious affections which have desolated humanity since that fatal day when Pandora had the sorrowful idea of opening the accursed casket.

When the apparatus is applied in hospitals it is desirable to impregnate the water flowing over the perforated plate with an antiseptic substance,—phenic acid or silicate of soda, for instance, the beneficial effects of which have so lately been discovered. In that would exist a certain means of destroying at any moment the morbific emanations contained in the air of hospitals. I particularly draw the attention of hygienists to this application of the apparatus. For a long time it has been a desideratum in hospitals, and this new system certainly furnishes it; and I do not hesitate to say that, if submitted to the impartial examination of qualified men in our academies, they will not withhold from it their valuable approbation. It is capable of a large number of uses at their hands unnecessary to name here.

I have often been struck with the bad construction of school-rooms; no ventilation, but the air hot and infected, and yet it is in such places that children pass a third of their lives. It has been said that of all the flowers, the human flower, that is to say, the child, has most need of the sun. Therefore let us see what the results of our physical education are. The ancients attached no importance to anything but outward forms—at the present day we have gone to the opposite extreme. Pass through our halls of study, the dormitories of our colleges, and you will answer me whether the university inspector, who once visited us in the narrow and stifling hall where we were shut up with Plato and Aristotle, was not in the right when he exclaimed: "What infection! what close heat!" and made his escape as fast as he could. If you had put a plant into such a hothouse it would not have thriven, and yet it is to such places that you send the object dearest to you in the world, a being requiring light, sun, fresh and pure air! It is barbarous.

As to the theatres, it is well-known that they are no better than ovens in the summer season. Whatever managers may do, the public goes elsewhere; the hot weather is for them a dead season which it would be well to revitalize. In winter theatrical spectacles would not be frequented if they were not heated; why then, reversing the operation, are they not refreshed during summer? If it were done the public would be as eager in that season to enjoy an agreeable spectacle, and the management would be considerable gainers by such a circumstance. That which I say of theatres applies equally to all other places of meeting: law courts, exchanges, deliberative assemblies—nay, the hall of the Institute itself, which, inhabited by the princes of science, is not less subject to atmospheric influences.

Another important application of this refrigerator may be made in steam-vessels. The companies charged with the administration of the great maritime lines are anxious, despite of the complaints we hear raised from time to time, to do all they can to procure comfort for their passengers by sea. Some little time ago—in fact quite recently—an innovation, having some relation to this class of idea, was proposed by the celebrated engineer Bessemer, and a company in adopting it has shown great good sense. Like the rotatory saloons of the English engineer, the air refrigerator of MM. Nézeraux and Garlandat would play an important part on the steam-vessels, whether as passenger boats or as freight ships laden with foods. This question has a double interest, for not only is it necessary to render life at sea more easy for travellers, and preserve the meats, &c., coming from a distance, but also to facilitate the service. All those who have sailed on board steam-ships know how much the excessive heat, in some countries, fatigues the engineers and stokers; it is not uncommon to see men brought up to the bridge in an entirely fainting condition. If the intense heat which prevails in those latitudes, and which at a stroke converts the ocean into a marble plain, where a frightful quietude reigns, does not always cause these dreadful accidents, it is not the less true that it enervates the men, doubles their fatigue, causes their work to be extremely irksome, and, in consequence, must tend to arrest the speed of the vessel.[1]

[1] The commander of the "Panamá" steamer, of the Transatlantic service, puts the matter in a very plain way:—"Coal bunkers are very well," says he, "with a railway system simplifying the transit of coals to the furnace-room. But these require great modification. The heat, so intolerable in all furnace-rooms, is particularly intolerable in this. There is no air, and the stokers are stifled. Their post is in the engine itself; it is too small and badly ventilated. It is quite pitiable to see their condition, and *I believe that the speed of the ship is diminished* by the difficulty of obtaining sufficient pressure."

I mentioned articles of food. It is a natural transition from the applications previously mentioned and those directly connected with manufacture.

I especially select the manufacture of beer, which every day assumes greater proportions. For some years this branch of industry has undergone important modifications, which have powerfully tended to augment the prosperity of this delicate speciality. Beer is growing more and more to be used in domestic life; in some places it is even supplanting the ancient beverage invented by Noah, which the refinements of modern science is banishing from our tables. An able authority said some time since that natural wine existed no longer; no doubt he meant to imply by this that the expense of that liquor, for forty centuries so famous, created an obstacle to its use in the home of the working-man, or at least favoured the development of those culpable industries in which its natural composition is altered. At the present day it is incontestable that the consumption is diminishing, and on the other hand that of beer is enormously increasing. In a few years, when the brewing industry will be in possession of economical apparatus sufficiently cheap to enable beer to be produced at low prices, and especially to ensure its conservation, beer itself will not fail to receive its letters patent of nobility. Recently a new discovery of the illustrious M. Pasteur will bring about an important amelioration in the production of beer; but the discovery of M. Pasteur, like every other discovery, requires completion. Another innovation, as happy as it was unexpected, that of MM. Nézeraux and Garlandat, has just arrived to bridge over the hiatus left by the former gentleman. It is certain that from the present time the manufacture of beer enters into a new phase, and that an enormous stride has been taken. From the present time France need not envy Germany its fair and sparkling liquor, any more than it need one day envy its cannon and its bombshells; with the other cannon—science—it will throw far the pacific bombs which carry vivifying resonances of happiness and prosperity into remote ages.

Temperature is one of the circumstances which have most influence on the quality of beer; so great is that influence that during the height of summer it is sometimes completely spoilt. The alterations which are the consequence of heat are principally shown by the viscous or lactic fermentations which appear during the process of brewing, during the alcoholic fermentation, and afterwards during the period of conservation. In the first case the loss is limited to a bad brewing; in the second it may reach a figure of formidable import. Therefore brewers of the very best repute have sometimes seen their losses amount to a very large sum, through this unfortunate cause of temperature. Besides, all brewers, if they look to their books, will confirm the fact that it has often penetrated to them; and they will allow that they have tried every means at their command to find a remedy.

The most favourable applications attempted at the present time have consisted in the employment of ice; but ice is not a certain palliative. Although this capricious and indocile substance has the advantage of being found abundantly in some places, it is not to be found in all; in some favoured countries, even, nature refuses to give birth to it. Added to this, ice does not always act in an efficacious manner, in consequence of its non-uniform nature.

Examining things closely, it is soon perceptible that in brewing beer there is no necessity to produce cold, properly so-called. In fact, cold would destroy the fermentation, or the sapidity of the liquor; now this is another inconvenience to be avoided. The object should be to avoid the excess of heat, so that the temperature should remain equable, and yet somewhat low. Such are the terms in which the problem should be stated.

Three principal processes are at work in the brewing of beer: the first is the refrigeration of the vats, the second the absorption of the excess of heat produced by fermentation, the third the regulation of the cellars. Now these results may be obtained by the use of MM. Nézeraux and Garlandat's apparatus.

I have not indicated the arrangement of the apparatus; it is for builders to decide upon that. But I should observe that the successive circulation of the same air columns would perfectly answer for the purification of cellars. The carbonic acid and all other miasmata would be instantaneously drowned in the water; thus purified, the air would be in a condition eminently adapted to absorb the miasmatic vapours disengaged in the cellars; as the circulation continued these dangerous vapours would be eliminated, and the interior atmosphere would remain fresh and pure. The operation need not be continued, it might be resumed at intervals; in ordinary circumstances it would be sufficient to put the apparatus in action for a few hours every day.

The special refrigeration of malt-houses has been the object of extremely ingenious researches, but they have been up to the present time unfruitful, if the various contrivances for the purpose be carefully examined. Competent writers have long since called the attention of science to the subject. Müller and Bulling on one side, Lacambre, Rohart, Payen have formulated a vow still re-echoing in the breweries; in Germany, Heiss, Habich, Vogel, and Siemens have also been in the affirmative. It will not be one of the least advantages of the apparatus of MM. Nézeraux and Garlandat that they can reply to a want so continually felt. For the cooling of the malt-houses it is sufficient to pass the air through a bed of cold water, without the aid of ice. In general well-water has a temperature varying from 10° to 12° Cent. By passing the air through the liquid bed a temperature can be maintained in the malt-houses not exceeding 12° to 14° Cent.; now that is the temperature necessary for the process. From the present time the brewers have the means of producing for themselves a malt of good quality, even in those seasons which least favour the operation.

Beers of high fermentations brewed in summer, even when they are made with substances "neat," the quality of which is superior to those used in the winter time, are inferior to those obtained during the cold season; and, what is worse, they deteriorate more quickly. One of the chief causes of this is frequently to be found in the high temperature of the places in which fermentation takes place, the temperature considerably stimulating the fermentation; a precipitate of sugar is transformed into alcohol, in consequence of which there is a great discharge of carbonic acid gas, and the beer retaining only a small quantity of the gas, the beverage does not possess the agreeable taste that a desirable liquid should contain; it easily yields to acidification, and scarcely acquires the limpidity forming not one of its least charms. For this kind of fermentation the apparatus working with water alone would be sufficient, as in the malt-houses, unless the brewer, having an ice-house, might wish to use ice, which would certainly produce the desired temperature in a very short time. It may be seen that the brewer, thus regulating the temperature of his cellars, might succeed in brewing his beer as successfully in summer as in winter, if the same care were always adopted in the process.

It is known that in the low processes of fermentation it is indispensable that the temperature of the cellars should be kept low and constant; this necessitates the construction at an immense expense of enormous ice-houses to refrigerate the air. This system has the disadvantage of being very wasteful; the air also remains charged with gas arising from the fermentation, which causes a necessity for double ventilation by the vent chimneys or air-holes; but at the moment of the cold air escaping it is replaced by warm air, which, in order to cool, causes the melting of a great quantity of ice. This inconvenience, it will have been seen, is overcome by the new apparatus.

In large establishments where beer is specially brewed by low fermentation the cellars where the fermentation takes place, as well as the cellars in which the beer is preserved, are built so as to command a constant temperature of from 5° to 8° Cent. for the first and from 3° to 5° Cent. for the second. In the cellars of the great establishments of Vienna, in Austria, even lower temperatures are maintained with great quantities of ice. The quality of those beers, so well accepted, does not arise from the peculiar manufacture; as essential causes it may be attributed to the quality of the prime article used, the care taken in malting, the buildings, the regularity in fermentation, as also in the sanatization of the cellars.

In France it is but rarely that brewers possess cellars of a requisite nature; sometimes the very moderate scale of the establishment does not admit of any expense. But the apparatus of MM. Nézeraux and Garlandat, accessible to any one, will permit French brewers to compete with foreigners and repel the importation of German beers.

Let us rejoice that science has succeeded in obtaining an amelioration so universally wanted; it is fortunate for brewing, a branch of industry very interesting to men of science. There are few industries, in fact, in which observations are more numerous or more various, which multiply and subdivide themselves into so many remarkable phenomena and transformations so full of interest to the student called upon to explain every one of the re-actions passing under his eyes; in one word, a brewery contains a whole system of organic chemistry. The most beautiful transformations of organic chemistry occur every day; every moment the starch of the cereals is converted into sugar in the act of germination, and by the contact of the air in the infusions. Later, the vegetable gluten and albumen separate and isolate themselves by the action of the fire during the boiling of the beer, and still later, fermentation changes the sugar into carbonic acid and into alcohol, which time, under the influence of the air, converts into acetic acid, and which science can transform into ethers, themselves transmutable into carbon and water, into oxygen and hydrogen, etc.

That which takes place in brewing is afterwards reproduced in alcoholic fermentations in general. The augmentation of the temperature rapidly brings on the acid fermentation, which does not take place except at the expense of alcoholic production. Thus this is, therefore, also a serious question for the distiller, and one of which the producer cannot take too much heed. In this case the air refrigerator might be used for the regulation of alcoholic fermentation.

Breweries and distilleries use a considerable quantity of grain. This grain is steeped for a certain time, and then spread in layers of 10 to 20 centimetres upon floors in places where the temperature is as nearly as possible 14° to 16° Cent. But it is very necessary that this temperature should remain equal. However well the malting-house may be situated, it is impossible to isolate it completely from atmospheric influence. The germination, also, does not take place without a certain degree of organic combustion; there is an absorption of oxygen and development of carbonic acid; in a word, by the proper action of evaporation the temperature of the mass is gradually raised, and soon passes the proper limit, if this is not remedied by turning over the beds of grain by means of large wooden shovels. This operation, by moderating the action of the temperature, allows the aëration of the entire mass to go on more readily. Not only is this hand-labour expensive, but it cannot be performed without crushing a certain quantity of grain, and if it be not done with regularity and care, the germination suffers, and a malt difficult to be treated is produced. This circumstance is so important, that malting is generally proceeded with in the spring and autumn months, when the temperature of the atmosphere is most favourable. If in brewing a certain amount of capital is required rather in excess of that wanted in other industries, in order to amass in three months a store sufficient for the whole year, it is still more difficult to do this in distilling; the mass of grain to be operated on is too considerable. Artificial means of regulating the temperature therefore becomes of more importance. To obtain the desired result it would be sufficient to substitute for the aëration supplied by the hand labour a current of fresh air.

By this means it would be possible to considerably mitigate the action of germination, and at the same time to get rid of the carbonic acid produced in the mass, a double circumstance allowing of regular and non-precipitous germination. This is all the more important, because a too rapid germination tends to destroy the starch. Now the starch, when transformed into sugar, yields the alcohol, and therefore when that which serves for the vegetation of the plant is lost, the amount of alcohol is diminished. It is therefore necessary to limit this vegetation and arrest the germination of the grain when a sufficient quantity of matter is produced. The refrigerator, properly adapted, will effect this, and therefore it should take an important place in an industry employing such a vast amount of capital.

As in beer-cellars, so also in the cellars of wine-growers, a constant current of fresh air is required, especially where effervescent wines are made. If this is not supplied the bottles burst and the wine is lost, spreading through the cellars a very sharp, mordant odour, and torrents of carbonic acid very dangerous to life are formed. Nor can this calamity take place without producing a great quantity of heat, therefore the thermometer rises at once in the cellars under such circumstances, sometimes even to 18° or 20°. Ventilation, under these circumstances, is almost always found useless; some wash the bottles with great quantities of fresh water, or even use ice; but considering that the average temperature of the cellars is 11°, in order to cool 1,000 bottles one degree it would require 40 kilogrammes of ice; and supposing the cellar to contain 12,000 bottles, when the temperature has risen to 19° it would require 3,840 kilogrammes of ice to bring down the temperature to 11°, and the bottles would also require to be washed. Very often well-water is cooled with ice and the bottles washed in the mixture, but the expense is the same. The applications for this purpose are all expensive, clumsy, and of little use. The use of the refrigerator would probably put an end to this inconvenience.

Many facts have combined to prove the energy of the elementary properties of chocolate, and we need not at the present day appeal to the authority of Madame de Sévigné to persuade the incredulous. Therefore there was great reason to apply industry to perfect the quality of this precious subject; chocolate of a good quality is not ordinarily to be met with; it is, as the proverb says, *rara avis in terris*. Perfect chocolate should be of a clear colour, it should be smooth, brilliant and compact; the cake should present a uniform texture, the grain being fine

and close together; it should not break without some force, producing a dry sound; it should melt softly in the mouth, filling the papillæ of the tongue with an aromatic taste, and leaving behind the impression of agreeable coolness; it should dissolve in milk or water without leaving the slightest sediment. These advantages are obtained by a judicious selection of the original materials in the first instance, and finally, by a manufacture as delicate as it is difficult. After introducing the chocolate into the moulds, forming it in cakes, prisms or cylinders of various dimensions, the vases are placed in the cool cellars. Generally, they are let down into the immense cellars called refrigerators, where the tablets harden, cool, and contract, which admits of their being taken from the moulds without difficulty. Now if, as is frequently the case in summer, the change of temperature is not sufficiently sudden from the workshop to the refrigerator, or in other words, if the cold attained by the product is not rapidly effected, the chocolate seems to lose its fineness and even texture; on fracture it is pale and granulous; it breaks *white*, as they say in the workshops, instead of presenting the sharp fracture of well-prepared chocolate. From this it results that the better sorts, by the simple influence of temperature, have the same appearance as the second quality. The manufacturers who have a desire to retain their reputation have occupied themselves greatly in remedying this inconvenience, which, in brief, might cause their productions to resemble inferior brands. Some practical men have tried to simplify the process, and thereby render it more economical, by using either ventilators, to produce a strong current of air, or other apparatus; at present the plans of M. Hermann and those of a well-known manufacturer, M. Dewinck, are in use. But the results have not been satisfactory, although large sums have been spent in the attempt; some factories have even been obliged during summer to suspend their activity. In this case the apparatus of MM. Nézeraux and Garlandat is applicable.

In the treatment of fatty substances, such as oleine, stearine, margarine, elaidine, palmitine, cocinine, and in the moulding of candles, it is also necessary to be able to command a supply of cooled air. Manufacturers have long since, with anxiety, called the attention of inventors to this point. It would be a new advantage to this eminently national industry to introduce a French invention into these factories.

A not less important application might be made in sugar refineries, in granaries, where large quantities of grain are stored; in silk-worm nurseries the plans of D'Arcet have been adopted, but found insufficient; the refrigerator would certainly prove itself well adapted for these.

I would willingly enlarge upon other industries in which the apparatus I have been led to prefer might be used. But there are limits to all things, and especially to the reader's patience. Intelligent manufacturers, for whom I have especially written this essay, may easily discover other applications of the new method.

Like every other fertile idea, it will not fail that among the enemies of every kind of advancement specious objections will arise. It will be alleged that the cooled air is susceptible of carrying with it too much moisture. It is easy to show that this objection is unfounded, and that, on the contrary, the moisture of the air on leaving the apparatus can be increased or diminished at will. I need not refer to the very simple and well-known plan by which this is done.

I have attempted to develop a question upon which very incomplete essays have been published. Finding among the many proposed solutions of an important question, one apparatus which, by its simplicity, utility, and economy, appears to meet every requirement, I have not hesitated to highly recommend it. "Publicity," as a distinguished manufacturer has said, "scatters abroad powerful seeds, which germinate and become fruitful in the minds of practical men." In place of sterile political discussions, in place of passionate recriminations, exclamations both emphatic and useless, let us contribute by every means in our power to assure the success of everything good, beautiful, just, and honourable. Let us propagate useful and philanthropic inventions destined to augment the well-being of our fellow creatures. This is the noble task of that sublime weapon, more powerful than all the swords in the world, the sabre which fights in the silence of the study, far from the noisy rumours of the world—the pen!

K. R. H. M.

GRINDING AND ENGRAVING BY SAND-BLAST.

THAT drops of water would wear away the hardest granite in the course of time, is a fact well known to observant men. The conditions are, that the drops should fall on the same spot in steady succession, and that their number should be millions—perchance countless millions. Every individual drop does its share of the work, too small to be detected by any human eye, or measured by any instrument of human contrivance; but still an effective working, a hollowing or indenting of the hard surface on which it falls. If the drop fall six inches instead of three, it will hit a harder blow and do more work; if twelve inches instead of six, the working energy will be still more marked; if a yard instead of a foot, still more; and so on; but the total result is measured in every case by the aggregate number of drops and the height from which they fall. It would be a trial of patience, but not an impossibility, to ascertain how many drops of water would bore a hole right through a slab of granite—the drops falling (say) twelve inches, and the slab being (say) one inch thick.

To a considerable extent, similar phenomena are observable when *sand* falls in a narrow stream or jet. The best sand is almost pure silica or flint, one of the hardest of mineral substances; and each little grain has a power of hitting a blow which has a definite dynamic value. If the sand falls simply by its own gravity or weight (as in the case of that which falls through the narrow neck from the upper bulb to the lower of an hour-glass or an egg-timer), the total working power exerted, or practical effect produced, would be measured by the number of grains and the height from which they fall. Under ordinary circumstances, our attention is not particularly directed to this kind of action, either when sand is simply falling, or when it is driven by some extraneous force; but we are not without some knowledge on the subject. At seaside pleasure-towns, where there is a wide expanse of sandy beach, it may often be seen that the glass of windows facing the sea becomes dull, or partially de-polished like ground glass. If minutely examined, the glass will be found to have an infinite number of tiny scratches on the surface; these scratches—really little digs or indentations—are produced by particles of fine hard sand driven by the wind against the glass.

These facts, and the principle they embody—the production of a perceptible result by the million-fold repetition of actions individually imperceptible—have been skilfully brought into requisition in America, by Mr. B. C. Tilghman of Philadelphia. He has devised the means of cutting, perforating, grinding, de-polishing, and engraving the hardest substances by the rush of a blast of sand, driven by a force much greater than that of gravity. He patented the apparatus for producing these curious results; his experiments have been fully described before the Franklin Institute; and the process has been practically shown at an exhibition instituted by that learned body.

The sand employed is hard and sharp, mostly silica; but it is selected with various degrees of hardness and sharpness according to the kind of work to be performed. The sand is driven by a blast of steam or of air—the preference being given to steam in some cases and to air in others. In the simplest form of apparatus, the sand is put into a hopper or upper receptacle, from which it descends through a tube: this tube being either vertical or inclined according to the kind of effect intended to be produced. A pipe of larger bore surrounds this tube; and a jet of steam, brought from any boiler suitably placed, rushes down through the space between the tube and the pipe. The effect of friction and impetus is such that the sand is compelled to share the velocity of the steam, when they come in contact at the mouth or lower end of the tube and pipe, and both are driven with great force against any substances on which they may fall. In practice, this substance is usually placed about an inch below the orifice; but the height may be varied according to circumstances. There must be a lateral escape provided for the spent sand, steam, and abraded particles, in order that the work may go on uninterruptedly; just as the fragments of rock bored through in sinking an Artesian well must be raised through the bore-hole and got rid of, in order that the boring may continue. If a blast of air is used instead of a rush of steam, a fan thirty inches in diameter is employed rotating with fifteen hundred revolutions in a minute. Steam in the form of a jet is used in the one case; steam-power to work the fan in the other.

The effect produced by these little torrents of fine, hard, sharp sand is something marvellous. A hole, an inch and a-half in diameter by about the same in depth, was bored com-

pletely through a solid piece of corundum in a little less than half-an-hour: the sand being driven by a steam jet at 300 lbs. pressure per square inch. When we bear in mind that corundum is one of the hardest minerals known, taking the lead in hardness of most gems and precious stones, and approaching almost to that of the diamond, we shall see the significancy of this experiment. On another occasion, when three different substances were operated on, steam at a pressure of 125 lbs. on the square inch was employed; a hole an inch and a-half in depth was bored in granite, in the same time that another of three inches depth was bored in marble, and of ten inches in sandstone—a useful measure of the comparative hardness of the three kinds of stone. A diamond was easily reduced in weight, and a topaz actually dissipated, by a sand-jet in one minute. A hole an inch long by a quarter of an inch wide was bored through a hard steel file in ten minutes; the file being a quarter of an inch thick, and the sand being driven by a steam-jet of about 100lbs. pressure on the square inch. With a pressure of about half this amount a hole was bored through a piece of hard granite, not by sharp grains of siliceous sand, but by small lead shot. This was a remarkable experiment, seeing that the lead shot was only slightly flattened, whereas the granite (so very much harder) was gradually worn away. The explanation is akin to that which applies to the lecture-room experiment of firing a tallow candle through a deal board: the candle has not time to melt, hardly time to soften, during its irresistible passage through the wood.

There seems every probability that many useful processes in the arts will be introduced through this singular agency. It will de-polish, producing grained glass or mat surfaces of metal, very readily. It may be made to shape stones or to drill rock by a sufficient amplitude of appliances. It will polish castings; there is some hope that it will cut types, perhaps engrave seals and gems; and it will certainly cut ornaments in wood. For acting on broad surfaces the fall of the sand from the lower end of the tube is made greater than for acting on small or narrow surfaces; the pressure of the steam or air is made to depend partly on the hardness of the substance to be operated upon; while by the use of diagonal tubes, and flexible-jointed connecting tubes, the jet can be turned in any direction, so as to produce grooves, mouldings, letters, figures, symbols, ornaments, and devices of various kinds, instead of merely boring holes or smaller cavities. In that description of iron-work called hardware, comprising cast-iron saucepans and other vessels, the sand-jet has been found useful in giving a clean metallic surface to the interior. The ware is usually turned in a lathe, before tinning the interior; but the sand-jet produces an equivalent cleansing effect, by wearing away a slight film of rough or dirty iron.

The capabilities of the new art, however, are more marked for purposes of ornament; and some of them are certainly remarkable. If portions of the surface of the stone are covered with some substance that will resist the action of the sand better than the stone itself, a pattern may be produced, made up of ground and unground, or engraved and non-engraved portions. The protecting surface here acts the part of a stencil-plate, as used in many of the ornamental arts. By laying such a stencil-plate on a sheet of glass the parts covered by the stencil remain in the usual polished state; whereas the parts underneath the openings of the stencil-pattern become de-polished by the action of the sand-blast, producing an effect analogous to that of decorative ground glass. Green fern-leaves, laid upon the glass, will suffice to resist the action; and thus a fern pattern in polished glass will be seen on a ground glass basis: provided the jet has only a small velocity or momentum. If a piece of fine wire gauze be placed upon the glass, the glass underneath the meshes may be not only de-polished but actually cut through, producing a sheet of perforated glass, with openings not more than one-twelfth of an inch in diameter, separated by little bars of polished glass only one-sixteenth of an inch wide. It has been truly observed that by no other known process could this beautiful result be obtained. Fine lace, if used instead of fine wire gauze, may produce a pattern of polished glass lace on a de-polished ground. One most curious production is a glass copy of an engraving. In the first place, the surface of a plate of glass is coated with bichromatized gelatine; on this a photographic negative of the engraving is taken; a jet of fine sand, urged at moderate velocity, is made to stream on this prepared surface; and a picture is produced by the unequal resistance of the gelatine to the action of the sand: those portions which have been most acted upon by light being different in their resisting power from the rest. The picture is thus defined by the glass being de-polished in varied degrees, producing a sort of light and shade. This appears to be a most fertile source of graceful ornament, susceptible of many suggestive applications, altogether exceeding anything that can be produced by glass-etching or glass-engraving. By a particular choice of the material to be operated on, effects of colour may be produced in an attractive way. For some kinds of crystal or cut-glass, the material is "flashed" during the making; the main portion consists of colourless glass, but this is dipped into a melting pot filled with molten-coloured glass; the glass-cutter then grinds away some of the red or other coloured surface, and reveals an uncoloured lower surface showing a beautifully coloured device on a purely white transparent ground. Now, this grinding away can be done by the sand-blast instead of the glass-cutter's small revolving tools, by placing a piece of lace, gauze, wire-cloth, or any open pattern, on the glass, and allowing the sand-blast to act just long enough to cut away the film of coloured glass only. A few seconds will sometimes suffice for the production of this novel effect—which is, in its nature, quite beyond the reach of any other mode of manipulation. As the sand-jet is never of large breadth or diameter, the glass is made to travel steadily on horizontally, so as to come equally under its action in all parts. The sand is not wasted; provision is made for conveying it up again into the hopper, whence it can be used over and over again. It may seem an anomaly that such comparatively soft substances as paper, lace, india-rubber films, fern leaves, or gelatine can resist the action of the sharp sand better than such a hard substance as glass; but it is ascertained, by microscopic examination, that each particle of sand at once digs its little hole in the glass, while the other substances give a sort of elastic rebound, like a buffer.

A process more recently devised by Mr. Morse, of New York, engraves the more delicate patterns without any steam or air-blast at all; the sand is made to do its work by simple gravitating descent.

We cannot doubt that there is a potentiality here of producing numerous valuable and elegant results.

ON FLOUR-MILL FIRE-EXPLOSIONS.

LAST year we were startled by the newspaper account of a violent, disastrous and lamentable fire-explosion which occurred in a flour-mill in Glasgow. A large building of five floors, besides a sunk flat and attics, had its gable-walls blown out, and was fired from top to bottom. The operations which were being carried on were of the most peaceful description, and were simply the cleansing and grinding of grain and the dressing of the flour. All the processes were proceeding in the most regular and harmonious manner, and yet in a space of time not greater than what is required to describe it—in a few seconds—two explosions took place; the mill was in ruins, the *débris* was simultaneously fired; the site of the mill was a roaring furnace, and, lamentable to relate, more than a dozen human beings were killed; in fact, out of twenty-seven work-people engaged in the mill, fourteen were instantly killed, one was mortally wounded, eleven were more or less severely burned, and only one, who was on an outer gangway, escaped unhurt.

The occurrence was so unusual, and at first sight apparently so unexplainable, that it called for a searching inquiry, in the prosecution of which the late Prof. Macquorn Rankine and Dr. Stevenson Macadam were requested to take an active part. The results of the investigation proved two points:—First, that there was nothing unusual being carried on in the special mill referred to which would render the operations more likely to lead to a fire-explosion than in other mills elsewhere; and, secondly, that fire-explosions of an exactly similar nature, though differing in degree, had taken place in other mills in this country and on the Continent, though the public, and even scientific men, were unaware of such. These facts enable us, on the present occasion, to take the particular case into the general question, and to discuss the subject simply in the light of an important public matter affecting one of the most necessary branches of technical science. The discussion of the subject will appear all the more necessary when we mention that, under the present arrangements of flour-mills, there is nothing to hinder another disastrous catastrophe happening any day; and we really feel it is a duty incumbent upon us to afford every possible explanation of the manner in which such fire-explosions have occurred and may still occur.

The nature of the operations carried on in flour-mills may be condensed under three divisions:—

1st. The cleansing of the grain.
2nd. The grinding of the grain; and
3rd. The sifting or dressing of the grain-flour.

In small mills these operations go on day by day with a

minimum amount of risk, so far as fire and explosion are concerned. One or more pairs of stones, enclosed in wooden framework, reduce the grain to powder, and the mixed flour and bran are conveyed by a spout to a bin, from which it is afterwards taken to the dressing-machines. Some of the finer particles escape into the atmosphere of the mill during the grinding and dressing processes, but the proportion is comparatively small, and, as a rule, is not sufficient in quantity to lead to a fire-explosion. At the worst, the fire-explosion will be limited to the pair of stones, which may strike fire, and possibly to the meal-spout attached thereto; or it may be localized in a dressing-machine when a light has been incautiously brought near the apparatus when in full work.

In a large mill, on the other hand, the danger of fire and fire-explosion is much increased, for ten, twenty, or thirty pairs of stones may be at work at one time; and each of these pairs of stones may have a box-pipe, roan, or conduit attached, which leads to an exhaust-fan, and the latter when in operation sucks or draws all the finer and lighter flour-dust up into a receptacle called an exhaust-box. The practical results of this exhaust arrangement are: (1) that the mill itself is kept more free from flour-dust floating in the air, and thus the men can work in a purer atmosphere; and (2) that it accumulates all the fine and almost impalpable flour-dust in the exhaust-box. Generally the exhaust-box is connected with a second dust receptacle called a stive-room, where the fine flour-dust which has not been deposited in the exhaust-box is received. Occasionally the exhaust is assisted in carrying away the fine dust by a blast or system of air-blowers.

Now the tendency of the exhaust system is to centralize and accumulate in the exhaust-box and its connecting stive-room all the fine impalpable flour-dust which does not readily fall by its own gravity through the meal spouts leading from the grinding stones, and, consequently, to store up for the time being those portions of the flour which can be most readily suspended through the air and form a dusty atmosphere.

Simultaneously with the employment of the exhaust, there have been introduced improved cleansing machines, including decorticators and smutters, for the prior treatment of the grain, and improved sifting or dressing machines for the more thorough separation of the different sorts of flour. All these improvements in milling have been carried out for the very praiseworthy object of perfecting the process, and of obtaining finer and, probably, better flour; but we are sorry to say they have at the same time brought about a condition of matters in many of our large flour-mills which may at any time lead to fire-explosion, as, in fact, has already taken place in several mills.

The chemistry of the grain and flour may assist us in arriving at an understanding regarding these fire-explosions. The chemical components are principally starch and gluten, with small proportions of gum, sugar, oil, woody fibre, and ash. The starch and woody fibre are composed of carbon, hydrogen, and oxygen ($C_6 H_{10} O_5$). So are also the gum, sugar, and oil, and the gluten contains these elements, accompanied by nitrogen, sulphur, and phosphorus. All these proximate constituents, viz., starch, gluten, woody fibre, sugar, and oil, are combustible when burned in the ordinary way, and are consumed with greater rapidity when diffused as a cloud through the air.

When the flour is showered from a sieve placed some distance above a gas flame, rapid combustion takes place; and, indeed, the flour burns with explosive rapidity, and the flame licks up the flour-shower somewhat in the same way that it flashes through a mixture of gas and air, or that it travels along a train of gunpowder. Similarly, the flour blown into a cloud by a pair of bellows at once takes fire and burns with a sudden and vivid flash. The smut taken from the grain during cleansing, and the sharps separated from the flour, burn with equal readiness. Probably the best way of showing the explosive combustibility of the flour particles is to place some flour in a box lying on its lid, introduce a light, and blow the flour into a cloud by bellows, when instantly the box is lifted from its lid, and much flame rushes out. The fine division of the flour has necessarily much to do with the rapid combustion; and, indeed, coarse gunpowder can be passed through a flame without burning, while fine iron filings cannot fall through the same flame without being set fire to.

When burned the flour resolves itself into gases, the carbon, by uniting with the oxygen in the air, becomes carbonic oxide (CO) or carbonic acid (CO_2), and the hydrogen and oxygen become water vapour or steam (H_2O). The volume of these gases is much increased by the high temperature at the moment of combustion.

The conditions required to bring about a flour-explosion are somewhat similar to those which cause a gas-explosion. Ordinary gas is combustible, and not explosive, when unmixed with air, and it only becomes explosive when it is mixed with sufficient air to burn it. This proportion is obtained in the most powerful degree when one volume of gas is mingled with ten parts of air. A lesser or a larger proportion of air lessens the power of the explosion, by causing the gas to burn less quickly, and, consequently, with less explosive force, and thus tending more to ordinary combustion.

The flour agrees with coal-gas in being simply combustible when unmixed with air, and equally agrees with coal-gas in being explosive when mingled with air in the proper quantities. The fine and impalpable flour-dust must be diffused through the air in definite proportions in order to constitute an explosion, when a white heat, such as a flame or spark, is brought near; and too little or too much of either of the components (flour and air) of the explosive mixture must lead to the lessening of the explosive force and to the more gradual combustion of the flour-dust.

In order to bring about the explosion, it is necessary also that the flour-air mixture be more or less confined within a given space; and hence if the flour be enclosed in a box with the lid fastened down, and the bellows be brought into play to produce a cloud whilst a light is introduced, the box will be forced open with a loud explosive noise, and the side be split up, whilst weights placed on the box are thrown off.

In fact, an explosion is brought about which resembles the effects of gunpowder, gun-cotton, and coal-gas. All of these will burn comparatively in a quiet manner when fired in open vessels, and it is only when enclosed, and resistance is offered, that the noise and effects of a true explosion are observed.

No doubt gunpowder and gun-cotton differ materially from the other explosive agents, as both the gunpowder and gun-cotton contain in themselves all the oxygen or air required to burn them, and thus do not need the admixture of air so essential to the explosion of coal gas and flour.

The order of explosions in flour-mills may now be referred to. The more common way of the production of the spark or flame which fires the flour-air explosive mixture is the feed going off the stones during work, when the stones set down on each other, and as they are of a flinty or hard silecious rock, and are revolving at from 100 to 160 revolutions in the minute, they quickly strike fire and become very hot.

The feed may go off from want of grain in the hopper, or from any obstruction in the feed-pipe. A spider's web actually stopped the feed in one case, and led to a violent explosion in an English flour-mill, where a detached stive-room luckily suffered most. Even when the feed is kept on, a nail finding its way into the hopper and down between the stones instantly strikes fire, and the minute particles of molten combustible iron inflame the flour-air mixture, and cause an explosion, as occurred in one of our Scotch flour-mills.

Probably the greatest danger is where the feed is suspended for a short time. The stones settle down and strike fire, and then the feed comes on again, in which case much inflammable flour-dust will be instantly produced and fired, and the exhaust will suck in the flame through the roans or conduits leading to the exhaust-fan and exhaust-box.

In several flour-mill fire-explosions the crackling noise of a running fire has been distinctly heard traversing the roans or conduits leading from the stones to the exhaust-fan. In some cases the explosion goes no furthur, and may simply blow open the fan-box cover, as in one case in Scotland. If the flame passes the fan, however, it gets into the exhaust-box, and everything depends upon the momentary condition of the exhaust-box at the time whether the explosion ends there, or the mill itself is blown up and fired. If the dusty atmosphere be at a minimum the explosion will be comparatively feeble, and will probably end in blowing out the side of the box, destroying some of the windows of the mill, slightly scorching a man or two, and loosening some timbers and slates, besides charring all woodwork within reach of the flame. But if the mill is in full working order, and much dust is being carried into the exhaust-box owing to the flour-air mixture being abundant, then the explosion will be violent; the sides of the box will go, and the fine impalpable flour-dust lying on the floor and shelves will be blown into the atmosphere of the mill, when a second explosion will occur and the mill itself must go—not only from one floor, but the explosion of the exhaust-box will cause a disarrangement of all the air-courses, and the mill being in communication on all floors by means of elevators, hatchways and other passages, and the cleansing and sifting processes proceeding at other parts, there must be a simultaneous production and firing of more or less flour-air mixture in all the floors, and consequent explosions. A period of darkness caused by the flour-dust being diffused through the atmosphere of the mill has been distinctly observed before the main firing of the mill.

The connection between the exhaust-box and the stive-room has

much to do with the direction which the explosion takes. Thus, if the mode of communication be by a wooden roan of small size, say a foot in diameter, as in many mills, the force of the explosion in the exhaust-box cannot spread itself in the direction of the stive-room, and must burst the sides of the exhaust-box, and force the explosive flour-dust mixture into the mill itself. But if the communication is capacious enough, say three or four feet square, then the explosion in the exhaust-box will find vent into the stive-room, and the latter, instead of the mill, will suffer. In an English case, where the latter conditions were carried out, the walls of the stive-room were blown out and the building wrecked, whilst the mill itself escaped with some charring of the wood. The stive-room, in this instance, was outside the mill, but the safety derived from the comparatively free communication between the exhaust-box and the stive-room would have been entirely negatived if the stive-room had been simply on another floor of the mill, as we have seen in one of the larger flour-mills in Scotland.

The chemical or physical results of the fire explosion may now be considered. An ordinary size of exhaust-box is 18 feet long, 9 feet high, and 7 feet wide. The capacity of this box will be 1,134 cubic feet, of which fully a fifth, or 230 cubic feet, will consist of oxygen. The quantity of coal-gas required to mix with this air, so as to form the most powerful explosive compound, is about 113 cubic feet; or taking the density of the gas at 500 (air = 1,000), less than 4½ lbs. of coal-gas. We all know how disastrous such an explosion would be, and yet only 4½ lbs. of coal-gas would take a part in it. With flour-dust, however, diffused through the air instead of the coal-gas, the proportion of oxygen contained in the box would be about 17½ lbs. weight, and would instantly burn 28 lbs. of the flour-dust into carbonic oxide, and water vapour or steam—being fully six times the proportion of the coal-gas which could be consumed with the same amount of oxygen.

The sudden combustion of the flour-air mixture at a white heat necessarily produces great increase in the bulk or volume of the gas, and when the whole conditions required theoretically for the production of the most disastrous explosion are practically realized in a mill, the increase of pressure is equal to eight atmospheres, which must necessarily bring about a violent explosion, and cause the destruction of any ordinary building.

The precautions to be taken in the future for the avoidance of flour-mill fire-explosions must necessarily lead to the removal of exhaust-boxes, stive-rooms, smut-rooms, and other receptacles of flour-dust to the outside of the mill, and it will be better if they can be placed at a side of the mill where there are no windows. There should be no direct communication between the mill and these places, except by the comparatively small spout or roan conveying the dust from the cleansing, grinding and sifting processes, and it will be better if the roans be provided with sliding or hinged valves which would close at once if an explosion occurred in any of the dust receptacles leading to a back draught.

The great sources of danger are undoubtedly the exhaust-boxes and stive-rooms, and these should be constructed either entirely of boarding, so that the explosion might readily find vent by bursting open the planks; or if built of brick or stone, the framework of the windows or other compartments should be loosely set in the building, so that they would readily give way when an explosion occurred. There are mills in Scotland more dangerous in their construction than those in which accidents have occurred; and we have one mill in particular in our mind at this moment, where the exhaust-box is on one floor and the stive-room is on the floor above, and both form part of the respective floors of the mill, and are only separated from the other parts of the mill by a wooden partition. If the necessary train of combustible and explosive dust leading from the stones through the exhaust-roans, fan, exhaust-box, and stive-room be complete through the full working of the mill, and a pair of stones strike fire from any cause, the mill we refer to can hardly be expected to escape a more or less disastrous explosion.

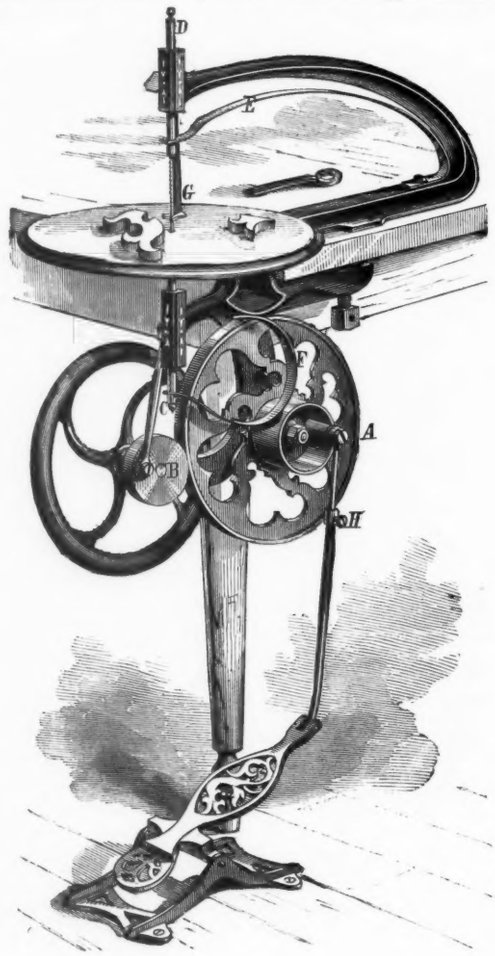
Not only should the exhaust-box and stive-room be outside the mill, but the danger will be lessened if the exhaust-fan be also placed outside. It can readily be put in the entrance of the exhaust-box, or in a corner thereof. Should an explosion then occur through the stones striking fire, it will be limited to the exhaust-roans, so far as the mill itself is concerned, and the fan will tend to suck the flame out of the mill. No one should enter the exhaust-box or stive-room during the working of the mill, and the cleansing out of these places should be carried on when the stones are not grinding.

No naked flame or light should be taken into any of the dust places, and all gas jets and lamps should be protected with glass and wire gauze coverings. Naked flames often lead to minor explosions in flour-mills, such as the firing of the dusty atmosphere in the dressing machines, and in some cases in the mixing-rooms where the different sorts of flour are intimately incorporated together.

We trust that this investigation will awaken the proprietors of all flour-mills to a sense of the necessity of adopting all precautions and measures to arrest flour-mill fire-explosions for the future. The plea of ignorance of the explosive nature of the flour-air mixture cannot now be pleaded. We do not blame mill-owners, however, for their want of knowledge in the matter of the powerful destructive force capable of being exerted by a flour-mill fire-explosion, for even science had not uttered a warning cry; and we know that the ablest scientific mill-engineer in the country, when asked for his experience and opinion in regard to such explosions, at once replied that he never knew of a mill being blown up by a mixture of flour and air, and that he did not consider it likely or probable that such could be the cause. And, to be candid, when we entered upon the inquiry we scarcely entertained the idea that a flour-mill could contain such elements of destruction within its ordinary operations, and it was only after organizing and carrying out many experiments, and fully considering the whole subject, that we were forced to the conclusion, which theory as well as experiment can now substantiate, that the ordinary arrangement of a modern flour-mill renders it liable any day to explosions of a more or less disastrous nature.

AMATEUR'S JIG SAW.

THE "Scientific American" reports:—We illustrate herewith an ingenious form of jig saw, designed especially for amateur use. It is portable and readily attached to a carpenter's bench or an ordinary table, by means of the screw clamp, as shown. The cast-iron arm terminates in the guide D, in which works the spindle to which the upper end of the



saw is attached in the ordinary adjustable manner, its lower extremity being similarly held in the guide underneath the table. A constant tension of the blade is maintained by the bent springs E and F. Motive power is communicated from the treadle, which may be attached, at any convenient point on the floor, to a rod which forms a sleeve for a smaller rod, which is connected with the crank of the large wheel A. The object of making the rod in two portions is that it may be adjusted to suit any height of table and afterwards held in position by the set screw at H. Around the circumference of the wheel A, is placed a covering of leather, by the friction of which the pulley B, and the fly-wheel connected therewith are actuated. By means of the pitman, as shown, motion is transmitted to the saw. G is an adjustable metal foot, designed for holding the work in place while being operated upon.

The machine is both simple and durable in construction, and, as a means of developing a mechanical taste in the young, will prove both a useful and instructive gift. It will readily cut out brackets, book-racks, and other ornamental articles, and thus may be used for profit as well as for amusement.

Patented through the "Scientific American" Patent Agency, July 23, 1872. For sale of rights, agencies, and for other particulars, address the inventor, Mr. Samuel N. Trump, or Mr. C. N. Trump, Machinist, Port Chester, N. Y.

THE INFLUENCE OF PHOTOGRAPHY ON ENGINEERING TASTE.

THE now extensive application of the art of photography to the illustration of machinery tends, it is to be feared, very greatly to injure the art of drawing as applied to engineering and architectural purposes. Before the adoption of sun pictures, if an inventor or manufacturer desired to convey to a client a clear and inviting illustration of any given structure, the picture had to be produced by some skilled artist; but photography does its work so well, so picturesquely, and so quickly, that it is now the means invariably adopted to illustrate machinery, and almost invariably to illustrate architectural subjects. Sun pictures, too, possess an advantage not existing about hand-made illustrations, which is that they are never available as working drawings; they cannot be scaled, and consequently inventors and manufacturers have no need to apprehend injury to their own interests in supplying photographs to strangers. Regarded thus, it is beyond doubt that photography is a valuable art to engineers and architects, but it is to be feared that its general adoption will injure and lower the more artistic portion of engineering and architectural drawing; indeed, such deterioration is even now progressing, for it is pretty well known that really first-class draughtsmen, men able and skilful enough to turn out artistically-finished coloured drawings, are not easily to be found.

There are cases sometimes in engineering work, when it becomes expedient to prepare a handsome and attractive picture of a new machine not as yet actually constructed, and therefore removed from the sphere of photography; similar cases must be of very frequent occurrence in architecture, as very generally it is desirable to have a good picture of the proposed structure, in order to judge of what it will look like when complete. Finished pictures of new machines as yet existing only in the brains of their inventors, or in the sheets of detail drawings, are rarely made, chiefly because the first, and even the second or third machine constructed, embodying perfectly novel features, is seldom perfect. The second is sure to differ in certain points from the first machine, and the third from both its predecessors; and thus it comes about that, at least in engineering, the draughtsman's art is lowered down to mere rough scheming sketches and plain rough working drawings.

It is matter of regret, that what may with some reason be designated as the only leaven of art present in engineering, should be eliminated. The question of pounds, shillings and pence exercises enough deterrent influence on any flights of fancy on the part of either engineers or architects, without removing the last little item of education in structural refinement remaining in the pupil's curriculum. Ten or twelve years ago it was possible, with a little trouble, to lay hands on draughtsmen capable of turning out with fair expedition, handsome, finished drawings of either engineering or architectural structures, but this cannot now be so easily done. The draughtsman's art will, or ought still to live, and even grow in the architectural profession; but there is not much chance of its doing so in mechanics. Regarded absolutely on its own individual merits, beauty of finish as applied to engineering drawings is doubtless of some, but not of paramount importance; but then it exercises what may be termed a moral influence on a pupil's mind. It is true that that perception of the beautiful commonly called taste is a quality that is innate, it must be born with the individual. No training can give it, but training will develope and vivify it; and it is here that the substitution of photography for hand-made drawings exercises an evil influence. The ability to draw good straight lines with pencil or pen, and to dab on washes and tints according to rule, is about the extent of the ambition of pupils in the present day; and the consequence is that, caring little about the finish of the drawing of a machine or a bridge, the student becomes equally careless as to the beauty of appearance of the design itself; and so long as the one does its work without breaking down, and the other sustains its traffic in safety, he troubles himself but little how either structure looks when complete.

The principal safeguard against the utter extinction of this branch of art exists in the schools established by the Science and Art Department of National Education; but unfortunately the engineering, or, we should more strictly say, the scientific department, is or was not long since placed on a footing inferior in status to that of art. As regarded by *savants*, this of course is perhaps right, but in ordinary popular education it is wrong. The aim ought to be to engraft the two branches to one stem, practically as well as in theory. Putting mechanics aside altogether for a moment, and considering civil engineering and architecture, who will venture to draw the line generally supposed to divide them? the engineer must be an architect and so *vice versâ;* but architecture is the mother of all the sections of fine art exemplified by the sculptor, and of much of the art of the painter as well. Therefore the engineer, if he professes to please the eye in his designs, must be likewise an artist. To form a just conception of how a given structure will look—a bridge for example—it must not merely be depicted on paper as a skeleton line drawing, but it must be coloured, it must have its lights and shadows worked out with skill and with cultivated taste, before a judgment can be passed on it; and to do this time is required, and also some training, something of education in art.

Engineering draughtsmen who aim at the production of handsome drawings have certain difficulties to contend against not encountered by the professors of fine art; their repertory of colours is limited. Colours as employed in engineering and in architecture are made use of not alone for picturesque effect, they are introduced as symbols of the various materials of the structure illustrated, and hence there is demanded both natural artistic taste and considerable training of hand and eye, and judgment as well, on the part of the person on whom devolves the task of producing a well-finished and attractive coloured drawing of a piece of machinery or of a building. The possession of such qualities, then, exercises a refining influence on their owners, raising their self-respect, strengthening their feelings of independence, and withal imparting that interest in their work so essential to success in life.

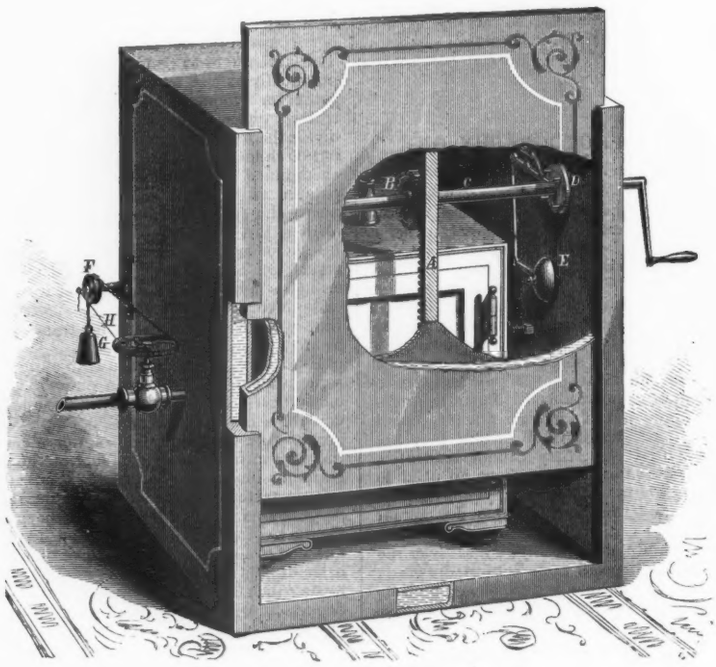
Some of our readers, perhaps, may think that we are attaching too much importance to what is termed mere mechanical drawing, that we exaggerate the influence so subordinate a department of art exerts on the well-being of those practising it, and on national taste as exemplified in its buildings and its machinery. We may reply to this by referring to a common adage in engineering, that "good drawings are indicative of good material and workmanship in the machinery itself." "Show me your drawings, and I will tell you what class of machinery you make," is a common enough paraphrase of a familiar maxim. The encouragement of care and excellence of finish in his drawings, when given to a pupil in an engineer's or architect's office, interests him in his profession, and is also attended with the good effect that it gives him an art whose practice affords an ever ready source of amusement for his leisure hours, at once innocent and inexpensive, and free from evil temptation and bad company. It may be asserted that when a young fellow has been cooped up in a close drawing-office all day he will hardly care to go home and sit at home all the evening working at nearly the same employment he has been at during the day. This objection can be thus answered: First, very many of the better class of pupils do so; many others avail themselves of the various schools of science and art to be found now in every considerable town in the kingdom; while a few have to stay at home from the fact of not having any money to spare for amusement abroad. A percentage of pupils, doubtless, frequent music-halls, theatres, and other less innocent places; but if the career of those who make a habit of going to such places be traced it will be found that they rarely are successful men in their profession.

The chief defect of the Science and Art Department of National Education is that the scientific branch is, as we have said above,

set below that of art. The prizes given for successful productions in art are superior to those awarded to the science scholars. This is not as it should be; in these schools art and science ought to advance hand in hand, and the student of engineering or of architectural drawing ought to receive as much encouragement in the way of prizes as is given to the art student.

Some persons deprecate the giving of prizes in these schools as an evil, alleging that the practice is an unhealthy form of stimulant, that it is encouraging the baser motives of self-interest, and not the abstract principle of doing what is commendable simply because it is commendable. Without doubt this is a very admirable doctrine in theory, but terribly unpractical—and this is a practical age. And if people refuse to be good unless they are paid for being so, it is perhaps better to pay them than let them go to the bad. We, however, altogether deny that a healthy spirit of emulation, as excited by a judicious system of prizes, is to be held as defective in principle; emulation is one of the most powerful influences in the human breast; and the pride felt by the student when he shows his parents and friends his medal or other prize, gained by a diligent attention to his scientific or artistic studies, is a pride of a good and healthy nature, conducing to self-esteem, to self-respect, to all those qualities which contribute to raise their possessor heavenward above vice and immorality.

No man can ever be either a great engineer or a great architect unless he is a man of large mind, and nothing helps more than educated taste, natural taste educated by the study and practice of fine art, to enlarge the understanding. Therefore, for this reason, if for no other, it is to be hoped that the art of drawing, as applied to engineering and architecture, may not be permitted to sink into insignificance simply because it is thought by some folk to be merely mechanical drawing, "a tedious and costly mode of arriving at effects reached more rapidly and at less expense by photography." H.



IMPROVED SAFE PROTECTOR.

THE "Scientific American" reports—Our engraving represents a new portable safe protector, designed to render ordinary fireproof safes more secure by enclosing them in an iron case, made with double walls, the hollow space between being filled with water. A continuous supply of the latter is maintained by connecting the protector to a suitable reservoir, situate in the upper part of the building, or to the ordinary water mains. The details of construction as represented in the illustration are as follows:—The rectangular case is composed as above stated, with double sides, top and bottom. The door is made to slide up and down in grooves, and is all hollow; and, by suitable connection to the supply, is filled with water. The safe, which may be of any desired variety, is shown through the broken away portion of the door, and is firmly held in position by jack-screws set up between it and the inside of the case.

The mechanism for opening the door consists of the rack A, attached on the inner side, in which works the pinion B, on the shaft C. This shaft is held in bearings in the sides of the case, and is turned by means of the crank shown. The outside end on which the handle fits projects in a recess, so that it is flush with the exterior of the wall, and may be of any peculiar or contorted shape so as to render an ordinary handle inapplicable. On the shaft just inside of the casing is a disk D, on which are a number of pins, which, when the shaft is rotated, strike in succession, and so raise a lever which is suitably connected with the gong E, causing the latter to sound and thus act as an alarm.

At the left of the drawing is represented the supply-pipe and valve, in a groove on the rim of the wheel of which is wound a small chain which passes over the pulley F, and sustains the weight G. As it is designed that, when in ordinary use, the casing shall not be filled with water, this apparatus is an ingenious means of admitting a supply automatically whenever necessity arises. The weight is sufficiently heavy to turn the wheel and so open the valve, but is prevented from so doing by the piece of common string H. In case of fire, however, this cord is at once consumed, and the weight falling, causes a constant supply of water to be admitted. Suitable vents may be provided to relieve the steam pressure due to intense heat. The water cannot rise to a temperature beyond 212° Fah., and as this is necessarily far below that which the interior safe is capable of withstanding, the protective qualities of the latter are greatly enhanced. The portability of this device will render it superior to the similar method lately suggested, and in some localities practised, of placing the safe in a permanent brick vault made with water connections.

Patented October 1, 1872. For further information relative to the sale of the entire right, &c., address the inventor, Mr. James W. Brook, Lynchburgh, Va.

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